ASSESSING USER REQUIREMENTS FOR AN AUTOMATED SYSTEM TO SUPPORT PROGRAMMED DEPOT MAINTENANCE THROUGH USE OF A RAPID PROTOTYPE IN A GROUP SUPPORT SYSTEM ENVIRONMENT

THESIS

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THESIS

Presented to the Faculty of the Graduate School of

Logistics and Acquisition Management of the

Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the

Requirements for the Degree of

Master of Science in Logistics Management

Floyd A. Gwartney, B.S.

Captain, USAF

September 1996

Acknowledgments

I would like to sincerely thank my thesis advisor, Dr. Alan Heminger, and my thesis reader, Ms. Barbara Masquelier, for their valuable guidance, encouragement and patience.

I am also indebted to Ms. Laurie Quill and Mr. Dave Kancler. Without your professionalism, knowledge of human factors and testing, as well as patience, this thesis would not have taken place. I thank you.

Finally, I would like to thank my wife Judy and my daughter Shelby for the understanding, and undying support that you have given me while completing this thesis and AFIT. I could not have made it without you.

Floyd A. Gwartney

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Abstract

The purpose of this thesis was to assess user requirements for an automated information system to support programmed depot maintenance (PDM). To accomplish this, the Integrated Technical Information for the Air Logistics Centers (ITI-ALC) program's rapid prototype was evaluated. The evaluation focused on users' perception of how well the prototype met system and human computer interface requirements for PDM technicians and managers. A group support system (GSS) was used as an analysis tool to evaluate the prototype and collect evaluation data. Using the prototype as a requirements baseline for the ITI-ALC system, this thesis had three objectives: to perform an assessment of the prototype and illicit modifications; to determine prototype compatibility with user's needs; and to investigate using GSS for prototype analysis. A total of seven users composed of PDM technicians and supervisors evaluated the prototype by following a scenario, and documenting their ideas using the GSS. Results indicate the prototype functionally meets user's requirements, however suggested modifications to enhance the prototype and gain more user acceptance. Results also indicate that a GSS is effective and efficient for performing prototype analysis. The primary recommendation was to make suggested changes and perform further tests to refine the ITI-ALC system baseline.

ASSESSING USER REQUIREMENTS FOR AN AUTOMATED SYSTEM

TO SUPPORT PROGRAMMED DEPOT MAINTENANCE

THROUGH USE OF A RAPID PROTOTYPE IN A

GROUP SUPPORT SYSTEM ENVIRONMENT

I. Introduction

Background

The focus of this study will be to assess the system and human computer interface (HCI) requirements for an automated information system to support aircraft programmed depot maintenance (PDM). The mechanism to perform this task is a rapid prototype developed for the Integrated Technical Information for the Air Logistics Centers (ITI-ALC), a research and development program being developed to support PDM process. This rapid prototype will be evaluated by qualified depot technicians and managers to determine how well it meets the needs of the intended users and what deficiencies currently in its design.

The Air Force is moving toward an increasing use of electronic storage, transfer, and presentation of information in the development, support, and operation of weapon systems (Masquelier, 1991). The force behind this shift to using digital data is the Continuous Acquisition Life-Cycle Support (CALS) initiative. CALS is a DoD and

industry initiative enabling the integration of digital technical information for system acquisition, design, manufacture, and support (Clark, 1992; Chapman & Simmons, 1995). Currently, much of the research and development toward implementing CALS into the support environment is focused on the delivery of digitized technical data for aircraft maintenance technicians working on the flight line.

An example of the CALS initiative is the Integrated Technical Information for the Air Logistic Centers (ITI-ALC). ITI-ALC is a developmental program that is extending information integration technology into the Air Logistic Centers for the support of aircraft depot repair and inspection (Masquelier, 1995). The objective of the ITI-ALC program is to analyze, and streamline the Programmed Depot Maintenance (PDM) process through the better use of available information. Depot maintenance is responsible for all the scheduled and unscheduled maintenance of aircraft and its associated systems and components, such as engines, landing gear, and avionics equipment. An effective depot maintenance process provides operating organizations with sufficient quantities of aircraft and serviceable items to train pilots and aircrews during peace and to fly combat missions in the event of war. Recent improvements in system reliability are reducing the time required for an item to flow through the depot process. However, this benefit is constrained by decreasing budgets for new systems, weapon system spares, and for training technicians. The need to use more effective and efficient ways to carry out the depot maintenance process is more critical today than ever before.

Computer and information technology advances are driving many projects to improve access to information that already exists within maintenance organizations (AL, 1995b). Other development projects have been directed to improve tools and maintenance aids for technicians. ITI-ALC is the first attempt to integrate electronically, the available information, tools, and aids for the programmed depot maintenance technician. The ITI-ALC system focuses on the maintenance technician's needs as the most important aspect of this integration process. The ultimate value of the ITI-ALC system and its acceptance by the end user is linked to the program's ability to achieve measurable performance improvements at the technician level (Masquelier, 1996).

ITI-ALC encompasses the computer and information technology required to meet the following specific objectives (AL, 1995b:1-1):

1. integrate multiple maintenance information sources into a single, easy-to-use information system
2. tailor information to meet the specific needs of the mechanic
3. eliminate time-consuming paperwork and tasks through automation
4. improve the quality of maintenance performance by taking advantage of the computer's ability to interact with and support the mechanic
5. maximize available manpower resources by providing information in standard, generic formats independent of the information system, and by supporting general technical capabilities at various skill levels
6. provide a link to the organizational level of maintenance to implement a more effective transfer of information between the two levels.

Problem Statement

A rapid prototype has been developed by the Logistics Research Division of Armstrong Laboratory to gather the information needed to create and refine a software baseline for the development of the ITI-ALC system (Figure 1).

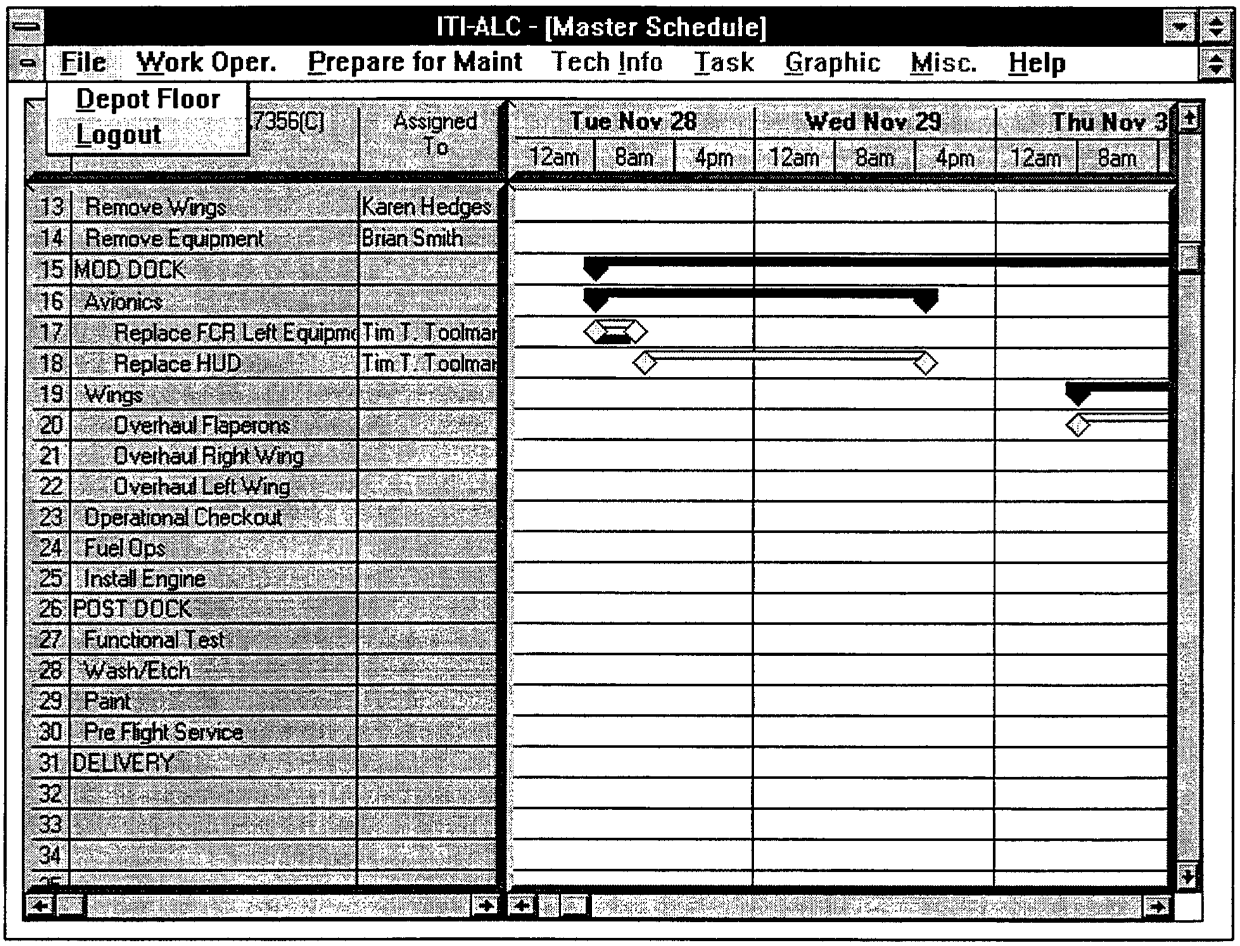


Figure 1. Example of ITI-ALC Prototype Screen (Quill, 1995)

The laboratory is interested in assessing user requirements for an automated system to support programmed depot maintenance. As a means to evaluate the user requirements, the ITI-ALC rapid prototype, that is based on previous requirement analysis, will be evaluated in a Group Support System (GSS) environment. The purpose

of the evaluation will be to identify any deficiencies in the current design relating to missing user requirements and potential user interface improvements. Incomplete requirement identification can lead to premature implementation of a system that does not fully meet its users needs. Likewise, those positive aspects that stand out in presenting the information will also be identified to ensure that these aspects are duplicated or at least not eliminated in the design of the ITI-ALC demonstration system. Even if all the requirements are implemented, if the user interface is developed poorly the system will not be accepted or used by the maintenance community.

Research Objectives

Objectives of this thesis research are to: (1) perform an assessment of the ITI-ALC rapid prototype and elicit suggestions for changes or modifications, to the current system requirements that are necessary for the initial baseline of the ITI-ALC system, (2) determine its compatibility with the user's needs, and (3) investigate the use of group support systems for prototype analysis.

The specific investigative questions for requirements deficiencies include:

1. To what extent has the current prototype adequately captured the user requirements for managing programmed depot maintenance and for performing a depot maintenance task?
2. If the prototype does not meet the users needs, what changes or modifications need to be made to correct the prototype system so that it does?
3. Does the ITI-ALC system present a "Value-added" to the user?
4. Does using a group support system aid in prototype analysis?

The specific questions for the usability of the user interface will include (Shneiderman, 1992):

1. Does the prototype meet user expectations when operating the system (e.g., is it consistent throughout)?
2. Can the user navigate through the interface easily?
3. Are screens organized in a logical manner?
4. Is the terminology used in the prototype appropriate?
5. Does the prototype minimize potential errors?
6. Is maintenance learning enhanced by the interface and prototype learning minimized (i.e., is it easy to learn)?
7. Are the system capabilities appropriate (e.g., is processing time too slow)?

Scope

This thesis research will evaluate the ITI-ALC rapid prototype developed by Armstrong Laboratory. The intent is to identify the extent and nature of any deficiencies presently existing, and suggest changes or modifications that should be considered when developing the ITI-ALC demonstration system. This thesis will also identify any currently missing system requirements needed to establish the initial baseline of the ITI-ALC system. This thesis will correspondingly investigate the ITI-ALC rapid prototype's compatibility with the user's needs. In addition to evaluating ITI-ALC, this thesis will also investigate the use of GSS for supporting prototype analysis.

II. Literature Review

Introduction

This chapter is a literature review of the areas critical to the success of this thesis. It was conducted to gain a better understanding of previous work and research that has been conducted in the respective areas.

This chapter is divided into four main sections. Each addresses a certain aspect of this thesis that must be investigated and then integrated to achieve the goals set for this study. The first section is a high level look at the Integrated Technical Information for the Air Logistics Centers (ITI-ALC). It investigates the purpose, objectives, and the overall concept of the program. The second section, reviews details of the rapid prototype developed to refine the functional and human-computer interface of the ITI-ALC system. The third section identifies current methods for performing usability analysis. The fourth section will investigate group support systems and their potential use in the ITI-ALC usability analysis.

Integrated Technical Information for the Air Logistics Centers (ITI-ALC)

The Integrated Technical Information for the Air Logistics Centers (ITI-ALC) is a research program being conduct by the Logistics Research Division of Armstrong Laboratory. The program is currently in its early stages and the initial requirements analysis for the program is nearing completion.

The purpose of ITI-ALC is to, "primarily improve the effectiveness of the mechanic who supports the weapon system at the depot" (AL, 1995c:1). This can be

achieved by providing the mechanic access to all the information necessary to perform the aircraft maintenance without them having to leave the job site. For example, any technical, diagnostic, or historical information that the mechanic needs to perform maintenance can be presented through a single device using single interface. ITI-ALC will provide access to integrated planning, scheduling, aircraft technical orders, and historical information to name a few. The type of information expected to be linked is graphically depicted in figure 2 below.

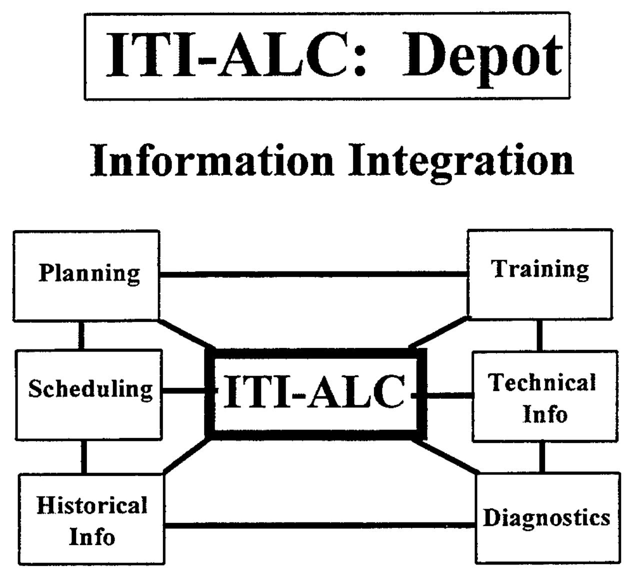


Figure 2. ITI-ALC Information Integration (AL, 1995)

The information is electronically linked, which eliminates the need for the mechanic to physically stop work and retrieve a specific Technical Order (TO) that he does not have. The fact that the information may come from several different data bases is transparent to the user because all the information is presented using a common interface and no reference to the source of the information is made.

ITI-ALC objectives

In order to make the goal of ITI-ALC come to fruition, six specific objectives were identified for the program. The first was to integrate all the maintenance information that the mechanic needs into a single information system that is easy to use. The second was to tailor the information to specifically meet the needs of the mechanic. The third was to automate the information, thereby eliminating time consuming tasks and paperwork. The fourth was to improve the quality of maintenance performance by taking advantage of the human computer interaction to support the mechanic. The fifth was to maximize the available work force by providing the information in a standard generic format that is independent from the source information system. This generic format would be able to support varying technical levels at the appropriate skill level. The sixth objective was to maintain a link to the maintenance organizational level bases and create a more effective information transfer between the depot and the organizational level.

A conceptual system configuration needed to achieve these objectives is represented in figure 3.

The ITI-ALC Concept

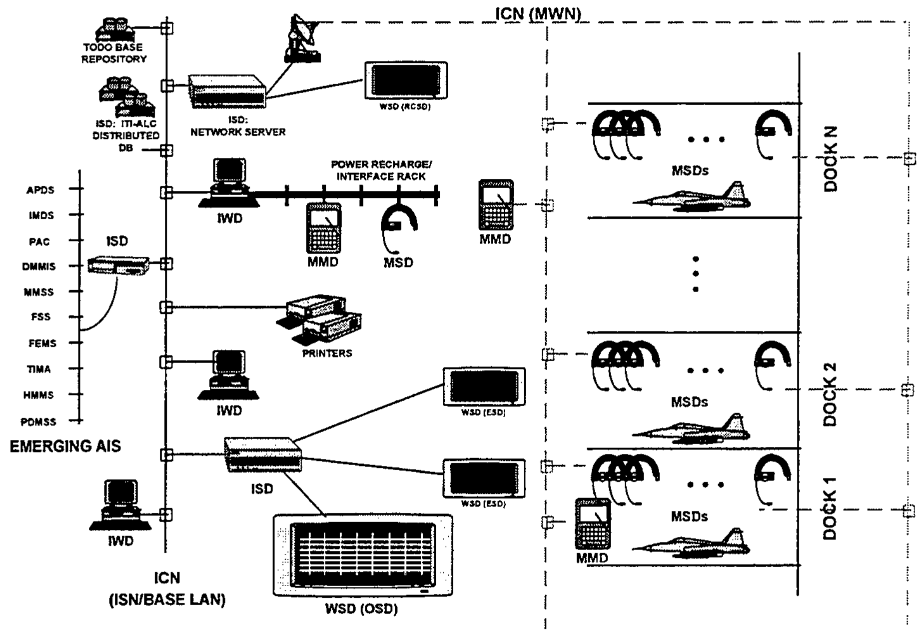


Figure 3. ITI-ALC Conceptual System Configration (AL, 1995c)

In figure 3, the databases that store the different types of information are located at the far left. As you proceed to the right, the multiple display devices are depicted which act as the means transfer the information from the databases to the mechanic. Going to the far right, the data is sent by radio frequency (RF) to the mechanic at the aircraft.

<u>ITI-ALC Requirement Analysis Approach</u>

To meet the objectives established for ITI-ALC, the current Programmed Depot Maintenance (PDM) process had to be identified and analyzed in order to streamline the process. "The process improvement was initiated from an information perspective" (AL, 1995b:1-2). As the starting point, the existing depot maintenance process was used to identify the initial functional requirements and to derive specifications for the ITI-ALC system.

Systems Research and Applications Corporation (SRA), the contracting agency performing the requirements analysis for Armstrong Laboratory, used a structured analysis approach in building the information models and functional requirements or the ITI-ALC system. The structured analysis approach allows the user's view of the maintenance environment to define the requirements of the system. "Successive decomposition of the models permits different groups of end users, to view the system from their own perspective" (AL, 1995b:1-2). Within context of the problem, each user viewpoint is maintained, while simultaneously providing each user with a view of the system that is familiar to them all.

Two types of models were developed during this requirements analysis, "As-Is" and "To-Be." "As-Is" models depict the current depot maintenance process and flow of information. The "To-Be" models describe an improved depot maintenance process. Analysis of the "As-Is" process and information models resulted in 15 Business Process Improvement (BPI) recommendations (AL, 1995a). The BPIs represent the addition of state of the art technology, changes to the parts acquisition process, and depot policy changes.

The "To-Be" models reflect an improved and streamlined PDM process that is expected to result in fewer maintenance flow days and lower operating costs. The overall objective of the ITI-ALC program is to improve the current PDM operations and to reduce the process time or the steps needed while creating a more effective and efficient PDM line. Emphasis has been placed on early integration of the BPI's into the design of the ITI-ALC system in order to reap potential cost savings upon implementation.

The accuracy of the "As-Is" and "To-Be" models that implement BPI's are critical to the success of the ITI-ALC program. This accuracy can only be achieved by maintaining a constant user involvement in virtually every step of the development process.

<u>User Involvement</u>

In similar programs proceeding ITI-ALC, the Logistics Research Division placed emphasis on the continued involvement of the end user. This philosophy led to many program successes. The same philosophy is being continued in the ITI-ALC program. The requirement analysis (Phase I) of the program began with interviews of those involved with every aspect of the aircraft PDM process. The interviews identified the functional requirements needed for the ITI-ALC system. These requirements were documented using an Integrated Definition Methodology (IDEF) which was used to create the "As-Is" and the "To-Be" models. The models were then taken back to the users at the depot to verify the process and information flow. This iterative process for developing the models continued until Armstrong Laboratory and the users at the depot were confident of the models accuracy.

User involvement in the development of a system such as ITI-ALC helps produce a better product and increase the likelihood of the users acceptance. It also gives developers a more realistic feel for the amount of effort needed to implement the user requested features (Boehm et al., 1984). The next step for the program was to develop the rapid prototype that would initially transform the requirements defined by the users into a testable human computer interface.

ITI-ALC Rapid Prototype

The ITI-ALC rapid prototype demonstrates the concept of complete information integration, by providing through a single seamless interface, access to planning, scheduling, parts ordering and maintenance repair information. The ITI-ALC rapid prototype was developed addressing two future users: the PDM mechanic and the Aircraft Manager (Quill, 1995). Functional flows for a typical PDM process were developed using maintenance experts from Armstrong Laboratory and depot personnel from Warner Robins AFB. Maintenance experts are a critical step in the building process because they posses an in-depth understanding of every step in the total process. These functional flows were developed by integrating information from the IDEF models and interviewing mechanics and aircraft managers at the depot. The functional flows were used to create storyboards for the rapid prototype and to show the BPI recommendations. The rapid prototype that resulted depicted 9 of the 15 BPI's planned for the ITI-ALC system (Quill, 1996).

The storyboards for the rapid prototype were not complicated. The screens were "simply sketched with a pencil on paper" (Pfauth, Hammer, & Fissel, 1985:467). The screens were then placed in a logical order and validated with the maintenance expert making corrections as necessary. The result was a typical PDM process flow on paper.

The storyboards that created a "Paper scenario" were then prototyped on line using Microsoft Visual Basic and Access. The result was a rapid prototype that has the planned HCI features and functional requirements of the ITI-ALC system.

Purpose of the rapid prototype

The purpose of the ITI-ALC rapid prototype is two fold. First, the prototype is used as a demonstration tool to help visualize the ITI-ALC concept. Second, it is used as a tool to obtain feedback from expected users on functional and the user interface requirements (Weiser, 1982). The prototype gives a good representation of what the user can expect to see in a fully operational depot system.

There are many benefits in using prototyping to develop a user interface. Prototypes can help the users to redefine, evaluate, and analyze their needs and requirements very early in the design process (Finger et al., 1996). The user involvement in the development process also helps increase the likelihood of user acceptance of the design (Kroenke & Hatch, 1994). In addition, prototyping used in the early phases of a development cycle can save time and money in the final software product (Greitzer, 1993). According to Lange and Bhavnani (1995:26), "the earlier the rapid prototyping process is considered in a program, the greater the rewards are."

Major benefits to prototyping in general as identified by Alavi (1984) and Foley (1986) and restated by Wilson and Rosenberg (1988:861) are:

(1) Provides a means for testing product specific questions that cannot be answered by generic research and guidelines.
(2) Provides a tangible means of evaluating a given user interface concept.
(3) Provides a common reference point for all members of the design team, users, and marketing.
(4) Allows the solicitation of meaningful feedback from users.
(5) Improves the quality and completeness of a product's functional specification.
(6) Increases the probability that the product will perform as expected
(7) Substantially reduces the total development cost for a product.

In order to evaluate the rapid prototype correctly and obtain the benefits outlined above, current testing methods and techniques were reviewed for applicability. The focus for the testing is the usability of the rapid prototype. Since the rapid prototype possesses many of the functional and HCI requirements of a fully functional system, its usability is representative of the fully functional ITI-ALC system.

Limitations of the rapid prototype

The ITI-ALC rapid prototype used in this study currently has limited robustness. It also has limited informational links to Technical Order (TO) and job guide information. The ITI-ALC rapid prototype has no true external computer interfaces and represents only part of the planning and scheduling functional requirements envisioned for the full capability. The rapid prototype does however, posses sufficient capability to answer the investigative questions posed for this thesis.

Usability testing

Usability is a term used through this thesis. In the context of this study, usability means that, "the people who use a product can do so quickly and easily to accomplish their own tasks" (Dumas, 1993:4). Dumas further elaborated by adding that the definition rests on four points (Dumas, 1993:4):

1. Usability means focusing on users.
2. People use products to be productive.
3. Users are busy people trying to accomplish tasks.
4. Users decide when a product is easy to use.

Since it is virtually impossible to anticipate all the problems that can be encountered in developing a system, usability testing is routinely employed as a means to

identify user problems early in the design phase. A multitude of variations exists in where and how a usability test should be conducted. Common to all, are five characteristics (Dumas, 1993:22):

> 1. The primary goal is to improve the usability of a product. For each test, you also have more specific goals and concerns that you articulate when planning the test.
> 2. The participants represent real users.
> 3. The participants do real tasks.
> 4. You observe and record what participants do and say.
> 5. You analyze the data, diagnose the real problems, and recommend changes to fix those problems.

Usability testing typically involves the use of task scenarios. A task scenario is a descriptive story describing typical use of the system. It tells the user contextually, what they are supposed to do during the test, but refrains from providing detailed specifications of the task steps. A realistic scenario also helps to take some of the artificiality out of the test.

The task scenario approach as a tool in usability testing is well accepted and was adopted in this study. The evaluation method needed to evaluate the rapid prototype was not as clear, so a further review of traditional evaluation methods was conducted.

Usability Evaluations

According to Hewitt (1986) and Booth (1992), usability evaluations can be divided into two separate types depending on the kind of information needed for the evaluation. The two types are formative and summative. A formative evaluation usually requires qualitative information that helps the designer refine a design and identify those parts of the system that need changing. Summative information, conversely, is more

likely to require quantitative information. Summative evaluation involves assessing the overall performance of the user and the system (Booth, 1992).

Different evaluations are used at different stages in the design of a system. For instance, qualitative information is needed when refining a design. It provides locations of errors and more explanation about the problems that the users encounter. In the later stages of design, the quantitative information becomes more valuable. The quantitative information helps assess the usefulness of the changes that have been made in the system.

Once the type of information needed for the usability test is determined, the method for obtaining the information can be chosen. According to Nielsen and Mack (1994), there are four basic ways of evaluating the usability of an interface: automatically, empirically, formally, and informally. An automatic evaluation is one where the usability measures are computed by running the specification for the user interface through an evaluation software to obtain results. An empirical evaluation is one where the usability of a product is assessed by testing the interface with actual users of the end product. The formal evaluation involves using exact models and formulas to calculate usability measures. Finally, an informal evaluation is based on general rule of thumb such as, "looking and feeling right," and the general skill, knowledge and experience of the users performing the evaluation.

Armstrong Laboratory has always focused on having the actual end item user provide feedback for making modifications or changes to a demonstration system (Johnson, 1991). The end item user is normally in the best position to know what is needed. End item users however, may have differing levels of computer experience.

In recent years there has been a substantial growth in the number of users who are not computer experts. An expert computer user is an individual that works with computers frequent and is comfortable with the task. To illustrate, a naive user's computer experience may be limited to computer games, or DOS based programs used on the job and those tasks may be rather repetitive. Eason (1976) termed these users as "naive."

The methods for obtaining usability data vary depending on the goal of the evaluation and the users opinion that is being solicited. Different users will look at the same prototype from a different viewpoint and as a result provide different kinds of information in their feedback. By specifying the objective of the evaluation it is possible to identify what measures you are seeking and what method should be used.

When it can be assumed that the user is naive, standard measurements such as time, number of errors, and qualitative information identifying what caused the errors can be used as valid measurement in the evaluation (Booth, 1992). When it can not be assumed that all the users participating in the evaluation are naive, the method used may be a combination of existing methods. Many methods of evaluation are available besides testing with naive users. Some of these methods as outlined by Booth (1992:124-127) are:

Concept test. A concept test is where only the theory or concepts of the system are laid out on a card or piece of paper and the presented to the user. The objective of this test is to identify those concepts that are acceptable, and those that are not that can, potentially create confusion.

Friendly user. Testing with friendly users involves using s from other groups that have interest in the system. Friendly users will usually have enough technical knowledge to suggest changes that might be made to the system. Friendly users are very useful in that they possess a reasonably good knowledge of the system, whereas naive users do not. A negative aspect to this method is that friendly users tend to miss aspects of the system that cause problems for the naive user simply because the naive user does not possess that increased system knowledge.

Hostile user. A hostile user is someone who has no vested interest in the system and therefore loses nothing if the system fails. The hostile user may identify inconsistencies or flaws in their critical review that would have created problems for the naive user. This is to say that a hostile user is more likely to be critical than a friendly user.

Simulating users. Simulating users is accomplished by charting the navigation through the system of a naive user. Later, when the time is more appropriate, that same system routing is replicated by designers. This approach provides an advantage in that the designer may take routes that were not anticipated in the original system design.

Structured Walkthrough. This approach is very similar to the simulating users approach. Designers in this method, walk through expected task routings searching for potential user pitfalls. The difference between the structured walkthrough and the simulation is that in a structured walkthrough the designers take paths that they think the user would use and simulation is based on actual user routing.

Expert review. In an expert review, the system is evaluated by a human factors engineer or designer that is not associated with the project. This hopefully removes any bias for,

or against the system. This approach has an advantage in that the comments are coming from someone who is knowledgeable about human computer interfaces. A disadvantage to this approach is that the expert is also doing the same type of work, even though not on the same project, as the system designers. This creates a potential for them to also overlook some difficulties that the naive user will encounter.

Simulation trials. Simulation trials involve using prototypes and mock-ups to test the intended system design. This method is usually used before a large portion of time and effort is expended on the first iteration of the design. It eliminates the designers feeling of extreme ownership and reluctance to change. This method also contributes to saving time and money because changes can be made earlier in the design.

Iterative informal laboratory experiments. This approach focuses on iterative refining of prototypes (Booth, 1992). In this approach, qualitative comments are used to iteratively modify a prototype, thereby eliminating as many problem areas as possible.

Formal laboratory experiments. Formal laboratory experiments add the element of control. This approach reduces the likelihood of the experimenter effecting the evaluation. Quantitative data are usually obtained and used to either support or refute an established hypothesis in this method. Disadvantages are that the users are removed from the normal working environment. This creates doubts that the responses of the user are a reliable indicator of the system being tested. Moreover, this approach tends to capture the users initial response to the system and learning issues, rather than the ease of use and efficiency of the system (Booth, 1992).

Audits. Audits are when the systems are is evaluated using checklists created from human factors literature. These checklists may include areas such as screen layout, or previously established hardware, or software requirements.

Field trials. Field trials are when the system is put into the organization that it was developed for, prior to formal release. This allows realistic studying of the system, but can be time consuming and make it difficult to gather data.

Follow-up studies. This approach is used to refine a system that has already been put into operation. Changes to the system from follow-up studies usually come in the form of version updates.

Field studies. Field studies are conducted within the organizations where the system is being used. They are typically more extensive than either field trials or follow-up studies and are harder to control than a formal experiment. The major advantage to this method is that it provides an accurate representation of how much the system is actually being used.

This list, although not exhaustive, provides an idea of some of the methods available to perform evaluations. "In reality, these methods are seldom used in a pure form, but evaluation tends to be something of a mix and match as far as methods are concerned (Booth, 1992:127)."

The evaluation conducted in this thesis will be a formative evaluation in that it requires qualitative information that will be used by designers to refine the ITI-ALC rapid prototype and identify areas that do not meet the users needs. The evaluation is also empirical according to the definition used by Nielson (1994), because the product will be

assessed with actual users of the end item product. The method that will be used in this study is not as clear. Using Booth's list of methods for using non-naive users, the method appears to be a combination of friendly user, simulation trial, and one iteration of an iterative informal laboratory experiment. To go a step further in combining methodology types, this thesis will explore using a Group Support System (GSS) to capture the ideas generated by the users for refining the rapid prototype.

Using a Group Support System

Over the past decade researchers, have explored a range of issues regarding the use of networked computers to support multiple users or teams in decision making (Heminger, 1988). GSS have been developed to help groups share their ideas or thoughts on a matter, organize these thoughts, and then vote on the options leading to a group consensus on an action. "GSS has shown to increase the effectiveness and efficiency of teams, by supporting and enhancing beneficial group processes, while circumventing or minimizing many of the counter productive aspects of group work" (Heminger et al., 1994:2). No instances however, could be found where the GSS has been used in conducting a usability analysis of any kind.

The GSS appears to be an untapped resource that could provide a new way of conducting usability analysis. At the very least, it presents an extreme potential for a faster and more efficient way of documenting qualitative information during a usability test. It also provides a means of allowing multiple users to simultaneously evaluate a product. A third benefit of using a GSS in usability testing is that individual evaluations can be conducted and the results immediately transferred into a group environment. The

ideas generated by the individual are still "fresh" in the their minds and the group can now discuss the ideas and possibly generate even more ideas as a result of the group discussion.

Group Support Systems

GSS is a computer based system, composed of a facility, hardware, software, procedures and facilitation working together to support and augment the efforts of work groups to complete an unstructured task (Heminger et. al., 1994:2). To date, GSS's have been primarily used to support business teams and quality action groups. This is expected to expand as the benefits of GSS are realized. Usability analysis may be such a case.

The benefits of GSS can be related to problems encountered in many traditional meetings (Fraase, 1991). For example, time can be wasted as people "go off on tangents" and stray from the issue at hand. Perhaps the personalities of a few of the participants may tend to dominate the meeting making the results biased toward those few individuals. In many cases, ideas can be lost because some users are shy or reserved or perhaps fear reprisal. Lastly, the minutes or records of the meeting are subjective or incomplete, and in some cases contradictory. This problem can be compounded when researchers rely on memory to recount the events because they have become "task saturated" as multiple deficiencies are being quickly discovered. The same problems could be experienced during a group usability analysis. These problems can cause meetings to become inefficient, ineffective, and unproductive.

Three characteristics of a GSS that make the meetings more productive can also make a usability analysis more productive. They are: anonymity, simultaneous and parallel processing of the information, and full and immediate recording of the information. The anonymity of the GSS system allows users to enter their comments and ideas without the other users knowing the input source. Those users that typically are quiet and more reserved in traditional meetings, are able to be more creative and assertive in entering their ideas. This allows ideas to be presented, that in a traditional meeting might not surface. The simultaneous and parallel processing allows the users to enter their ideas at the same time. Each user has the potential to "feed off " the others ideas allowing group ideas to more quickly evolve. This characteristic can also serve to speed up the analysis and accelerate what can be accomplished because everyone is presenting their ideas at once, yet all the ideas are being presented without interruption. Finally, the full and immediate recording of the information and transpiring ideas are automatically recorded and available for printing immediately after the meeting. The researchers do not have to rely memory or the accuracy of the individual recording the results of the analysis.

Summary

This chapter investigated four areas critical to the success of this thesis: the Integrated Technical Information for the Air Logistics Centers (ITI-ALC) program, the ITI-ALC rapid prototype developed by Armstrong Laboratory, different methods for performing usability analysis, and group support systems.

The Integrated Technical Information for the Air Logistics Centers (ITI-ALC) program was researched in order to understand the concept of the system and what is required by its expected user. Continuous user involvement has been the standard for developing the ITI-ALC system. Literature indicates that this type of philosophy produces a better system at a lower cost and fosters more of a "buy in" support for the system from the end item user (Greitzer, 1993).

The second area researched in this literature review was the ITI-ALC rapid prototype developed by Armstrong Laboratory. The prototype is a next step in the iterative design process. It builds on and implements the initial requirements analysis for the program. It also provides a platform to help verify functional and human computer interface requirements for a fully functional information system. The prototype highlights business process improvements that are expected to save money and time over the current PDM process.

In order to accurately evaluate the rapid prototype, several methods for evaluating the usability of a system were reviewed. The method chosen is a combination of three standard methods: Friendly user, Simulation trials, and Iterative informal laboratory experiments. These three methods will be combined to tailor a method for this study. The resulting method will be coupled with an apparently untested approach of using a group support system to perform the usability analysis.

Group support systems (GSS) were investigated as a possible untapped resource that can be used in prototype analysis. GSS may be a means to more effectively and efficiently perform usability analysis given their successes in group processes. The

anonymity it provides to users combined with the automatic documentation of ideas makes it an intriguing possibility.

This literature review is the starting point for this research that is to perform an evaluation of a rapid prototype that has been developed for the Integrated Technical Information for the Air Logistics Centers. The following chapter will describe the methodology used to evaluate the ITI-ALC rapid prototype.

III. Methodology

Chapter Overview

This chapter explains the methodology necessary to evaluate the ITI-ALC rapid prototype. First this chapter will present the experimental design and the projected study results. Second, it will describe the equipment used during the evaluation. It will then discuss the tasks and the subjects chosen for the study and finally, it will explain the data collection procedures and analysis necessary to answer the objectives outlined for this thesis.

Throughout this thesis, the participants in this study will be referred to as users. In addition, the ITI-ALC rapid prototype will be referred to as the prototype, and the group support system used to collect data will be referred to as the GSS.

Experimental Design

Objectives

The experimental design for this study was developed to achieve 3 major objectives. The objectives are to: (1) perform an assessment of the ITI-ALC rapid prototype and elicit suggestions for changes or modifications, to the current system requirements that are necessary for the initial baseline of the ITI-ALC system, (2) determine the ITI-ALC rapid prototype's compatibility with the user's needs, and (3) investigate the use of group support systems for prototype analysis.

Method

The method of evaluation defined for this design was a combination of three methods outlined by Booth (1992). The design was a simulation trial, conducted with a single iteration laboratory experiment using friendly users. Users utilized the rapid prototype during an evaluation, and made comments as they went through the depot process scenario. Because of their experience, the users provided an element of system knowledge, about the process that the ITI-ALC demonstration system is being designed for.

Sample population

The target group for this study was aircraft depot maintenance technicians, functional supervisors or managers for the aircraft programmed depot maintenance line, at Warner Robins ALC, GA. All users sampled were either currently performing the job they represent, or have recent experience in that position. Seven users were chosen from the target group to evaluate the ITI-ALC rapid prototype.

> Seven users have been deemed adequate for this study based on a finding by Robert Virzi that 80 percent of usability problems can be detected with four to five subjects and the addition of more subjects is less likely to reveal any more problems in the application being evaluated. Virzi went on to say that the most severe problems in the application tend to be detected by the first few subjects. (Virzi, 1992)

Projected Study Results

The expected results of this study and their anticipated use by the sponsoring agency are as follows:

1. Improved understanding of ITI-ALC suitability in satisfying user needs by identifying those rapid prototype features that worked well, and those did not.

2. Feedback from the users in this study will provide insight into the changes that should be made to the evolving design concepts for the ITI-ALC system development and those features which currently meet or exceed user's needs.

3. The ideas collected in this study will be made available to Armstrong laboratory to provide to the contractor developing the ITI-ALC demonstration system.

4. This study will illustrate the potential value of group support systems in future usability studies.

Hardware

The ITI-ALC rapid prototype and group support system were presented on 386-based computers operating at 25 MHz with 16 MB of RAM. All computers are in the groupware laboratory located in room 319 of building 641, at the Air Force Institute of Technology (AFIT). These computers and terminals are typical of those expected to be used to support the fully functional ITI-ALC demonstration system in the air logistics centers.

Software

The software for this study includes two separate software packages running with a Windows 3.1 operating system. The first is the ITI-ALC rapid prototype developed by Armstrong Laboratory. This rapid prototype was developed using Microsoft Visual Basic 3.0 Professional and Microsoft Access 2.0. The second software package is the GSS and is Ventana GroupSystem for Windows. This package will serve as the collaborative software to facilitate data collection for the rapid prototype evaluation.

Each user was asked to review the rapid prototype and document the results of the evaluation using the group support system. The capability to switch between active tasks was granted by using the Alt-tab key combination available in Microsoft Windows. This capability allowed the user to review the rapid prototype and immediately switch to the GSS to document their ideas or comments about the rapid prototype.

Room Equipment

The room was equipped with 8 user terminals and 1 facilitator terminal connected in a LAN network. A user terminal is a terminal where the person that is performing the evaluation sits. This terminal is granted control by the facilitator terminal. The facilitator terminal is the master terminal where the GSS software is controlled. The terminals were arranged on tables placed on tables pushed together at the sides because of the space limitation in the room. It also had a single overhead projector equipped with LCD panel display to allow the information being presented on the facilitator terminal to be simultaneously viewed by the group on an overhead screen. This allows the group to look at the same screen and conduct group discussions. The room was also equipped with two white boards to aid in group discussions.

Task

During the evaluation, each user reviewed the ITI-ALC rapid prototype by stepping through an established scenario (Appendix B). As the users performed this walkthrough of the established scenario, they documented their comments using the group system software. The group system software used for this study was the Ventana GroupSystem

for Windows. This software served as a tool to collect and present the ideas for improving or modifying the rapid prototype. These ideas were subsequently rated on a scale from 1 to 10 by each individual. The rating results will then combined, creating an initial ranking of all the group ideas

The user centered workshop plan in Appendix A, describes the details of the evaluation. It details the sequence of events to include introductions, tutorials and the evaluation phases.

During the evaluation, observations were made of the users interacting with the prototype. These observations were documented on packages that showed each prototype screen in the scenario in the same sequence as the users were looking at during the evaluation.

After the evaluation, each user was asked to fill out a questionnaire that addressed specific areas dealing with the usability of the prototype. The areas of this usability questionnaire correspond with areas typically looked at by HCI engineers when developing an information system.

Data Collection

The data collected in this study is largely qualitative in nature. Two data collection tools were used, questionnaires and the group support system. Two separate questionnaires were given to each user. The first was a biographical questionnaire that was seeking personal information, depot experience, and the individuals familiarization with computers and software packages (Appendix C). The second questionnaire was directed toward the usability of the prototype (Appendix D). This questionnaire was

administered at the conclusion of the test to gather any remaining comments or suggestions as well as their overall impression of the prototype.

Ideas and comments obtained during the evaluation of the prototype contribute to the information needed to answer the functional and user interface questions identified in chapter 1. The rating of the user's ideas was also collected using the group support software and established a prioritization identifying how important each particular requirement is to the user (Nielson, 1992).

Observations in the form of notes and comments on a paper copy of the scenario were also collected during the session. (Appendix H). The notes served to capture information subtleties that constitute the intangible nuances or "feel" of the user using the prototype.

Controls

The goal of this study was to gather uninhibited ideas on the ITI-ALC rapid prototype to identify missing requirements and usability problems of the system prior to its final design. The nature of this study was to therefore have limited controls and to place minimal restrictions on the group. Some controls however, were unavoidable in order to maintain the integrity of the results. These controls are as follows:

1. All users were from one base to eliminate variability in accepted local maintenance operating procedures.

2. The group walked through a single scenario during the initial evaluation to ensure that every user saw the same screens and was asked to perform the same tasks.

3. The Group software laboratory was isolated from outside activities to keep distractions to a minimum.

Data Analysis

The following information measurements will be used to analyze and draw conclusions toward answering the objective questions identified in chapter 1 of this thesis.

a. A ranked list of ideas identifying potential changes to the rapid prototype.

b. The consolidated ideas will be categorized into groups or areas of concern.

c. Explanatory comments provided by the users for each idea will help clarify the meaning and provide recommendations on missing human-computer interface or functional requirements.

d. Individual assessment of the prototype as obtained in the usability questionnaire.

Specific investigative questions and the means for answering the questions to identify requirement deficiencies are as follows:

1. To what extent has the current prototype adequately captured the user requirements for managing programmed depot maintenance and for performing a depot maintenance task?

Measurements 1, 2, and 3 in combination with measurement 4, the usability questionnaire items 1-26 contributed to answering this investigative question.

2. If the prototype does not meet the user's needs, what changes or modifications need to be made to correct the prototype system so that it does?

Measurements 1, 2, and 3 in combination with measurement 4, the usability questionnaire items 1-26 contributed to answering this investigative question.

Measurements 1, 2, and 3 specifically address the information needed to answer this investigative question.

3. Does the ITI-ALC system present a "Value-added" to the user?

Item questions 1, 2, and 24 of the usability questionnaire provide the information needed to answer this investigative question.

4. Does using a group support system aid in prototype analysis?

Only three questions on the usability questionnaire addresses this question. Item 27, 28, and 29 seek the feedback that answers this question.

The specific questions on usability include (Shneiderman, 1992):

1. Does the prototype meet user expectations when operating the system (e.g., is it consistent throughout)?

Items 1, 2, and 3 of the usability questionnaire seek the information for this user interface investigative question.

2. Can the user navigate through the interface easily?

This question is addressed by various portions of measurement 1, 2, and 3 but is not solely from any one. Items 6-10 of the usability questionnaire specifically address this investigative question.

3. Are screens organized in a logical manner?

Measurements 1, 2, and 3 address aspects of this question along with items 4 and 5 of the usability questionnaire.

4. Is the terminology used in the prototype appropriate?

As with many of the previous investigative questions, measurement 1, 2, and 3 in part address this question. Items 11-13 of the usability questionnaire directly addresses this question.

5. Does the prototype minimize potential errors?

Measurement 4, the usability questionnaire directly addresses this question in items 14-17.

6. Is maintenance learning enhanced by the interface and prototype learning minimized (i.e., is it easy to learn)? Items 18-21 in the usability questionnaire addresses this investigative question.

7. Are the system capabilities appropriate (e.g., is processing time too slow)? Items 22 and 23 in the usability questionnaire addresses this investigative question.

IV. Results and Analysis

Chapter Overview

This study was designed to gather information in three forms: group prototype evaluation results, individual prototype usability results, and observations made on user-prototype interaction. This chapter describes the subjects used in the evaluation, presents the results obtained in each form of data collection and analyzes the result as they pertain to each of the investigative questions stated for this thesis.

Subjects

The evaluation of the rapid prototype was conducted using a total of 7 users composed of programmed depot maintenance (PDM) technicians and functional supervisors or managers for the aircraft depot line at Warner Robins ALC. Each user evaluated the prototype based on personal knowledge of the depot maintenance process, the information currently needed to perform the maintenance and planning tasks, and the manner that the information was presented to them. User testing such as this can answer many questions that cannot be addressed using a generic user (Gruenenfelder and Whitten, 1984). The individuals personal knowledge and expertise in the depot maintenance process were invaluable for an accurate review of the functional requirements and the graphical user interface used to present the technical orders and information to the user of the ITI-ALC demonstration system (Plato, 1995).

Prototype Evaluation Results

The results collected in each of the methods in many cases provide overlapping or duplicate information. Conversely, some information that was collected was found to be unique to the method used in the data collection.

GSS Results

The prototype evaluation using the GSS was a 3 step process. The first step was to generate ideas and supporting comments as the users walked through a pre-defined scenario. The second step was to rate each idea according to the idea's criticality to a fully functional ITI-ALC system as perceived by the users. The third step was to place the ideas into categories typically used by human factors engineers in Armstrong Laboratory when evaluating information systems and their user interfaces. The categories were user expectation, screen, navigation, terminology, errors, learning, and rapid prototype capabilities.

Evaluation step 1:

The GSS, in the first step of the evaluation, captured user ideas and comments relating to the prototype. Those ideas and comments are listed in table 1.

Table 1. User generated ideas and comment for the ITI-ALC prototype using a GSS

GSS Documented Information
IDEA GENERATED BY THE USERS • comments made to support and explain the idea generated
1. TECHNICAL ORDER GRAPHICS WERE INSUFFICIENT IN SOME AREAS
• graphic doesn't show gap tolerance
• picture of rack not sufficient
• graphics should be displayed full view on entry and be able to zoom in on specific areas

Table 1. User generated ideas and comments for the ITI-ALC prototype using a GSS (Continued)

• need more than one view on locator area around work needs to be more detailed
• add menu capability for exploded views.
2. TECHNICAL ORDER PRESENTATIONS WERE INSUFFICIENT IN SOME AREAS
• need capability to mark last completed step (e.g., bookmark)
• warnings before starting tasks are very helpful.
• to ensure proper recognition of icons computer classes for all mechanics a must.
3. PROBLEMS WITH REVIEWING AIRCRAFT PREVIOUS WRITE-UPS
• needs to be reworded to reflect "previous" in lieu of o level
• bad menu choice o-level history
• spell out "o level" to organization
• don't abb. menu items
• have write ups come up before job is started
• how do you get to previous write-ups
4. CHANGE DISPLAY OF AIRCRAFT OPERATION STATUS
• status bar is difficult to read, would rather see a time line of operation showing completion
5. MODIFY CHARACTERISTICS OF AIRCRAFT IDENTIFICATION
• Selection of aircraft should be consistent with other selections. Single mouse click without watch symbol confusing. Double-clicking caused work form to update.
• are these aircraft tail numbers? which is assigned to me? highlighted aircraft signify managers aircraft
• identify which aircraft belongs to which aircraft manager. this information would be useful in can items. (read only)
• provide history of aircraft configuration - which TCTO's have been complied with? - what special work has been performed?
• need bldg location i.e. bldg number and bay
6. MASTER SCHEDULE ..BAR GRAPH COLORS NEED TO BE EXPLAINED. EX. RED- BEHIND SCHEDULE, (Legend)
7. GET READY TO DO MAINTENANCE
• on parts source what is none
• need to reflect between age and test equipment

Table 1. User generated ideas and comments for the ITI-ALC prototype using a GSS (Continued)

• need to show ordering status
• can't perform task unless equipment is available
• need further instruction on how to order equipment
8. PLANNING INTERFACE REQUIREMENT NEEDED
• need interface with planning organization as with problems in process such as TCTO compliance, e.g., cams indicates a TCTO being c/w when actually it's not
• need interface with engineering for 202 requests and also AFTO 22 requests
9. MECHANIC SHOULD BE ABLE TO RETURN TO ANY TECHNICAL ORDER TASK WHEN DOCUMENTING MAINTENANCE PERFORMED
10. GROUP PERTINENT AIRCRAFT WRITE UPS WITH WORK AREAS
• Group tasks by physical location.
11. 173 CARDS NEED TO BE SHOWN ON THE SCREEN WITH SPECIFIC NUMBER OF PERSONNEL REQUIRED
• inspection code should be predetermined, not an option. Critical requires 2, non-critical requires 1
• Need to allow one signature box for each person signing the "card."
12. ADD FIELDS IN SUPPORT EQUIPMENT SCREEN
• need to show part number
• fed. stock number, and nomenclature.
13. CAPABILITY TO REINITIATE TECHNICAL ORDER ALERTS WHILE PERFORMING MAINTENANCE
• have capability to reinitiate alert from the menu or icon (step 7).
• like aircraft locator
14. SCREEN SHOWING AGE EQUIPMENT BACKORDERED WAS UNCLEAR
• has equipment on backorder already been ordered or does mechanic need to order?
15. HOW TO CLOSING OUT WAS NOT CLEAR FROM TASK TO TASK
• wording unclear could not find sign off
• have an exit button to log out
16. HOW TO MAKE A MECHANIC ASSIGNMENT WAS CONFUSING
• did not know clicking on mechanic name was way of selecting name

Table 1. User generated ideas and comments for the ITI-ALC prototype using a GSS (Continued)

17. THE LOGON GRAPHICS WERE GREAT!
• Aircraft fly-by
18. PROCESS WAS EXCELLENT
• scenario was excellent

Based on group discussions, the ideas are further described as follows:

Idea 1. "Technical order graphics were insufficient in some areas." This is in reference to graphics within the digital technical orders (T.O.). The graphics presented are directly from the paper T.O.'s presently used by depot technicians. The comments made by the users' center around the capability to see the details of the graphic within the window provided in the prototype. One other comment highlights the omission of a gap tolerance that was either already presents in the T.O., or omitted in the scanning and "cleaning" process of digitizing the T.O. data.

Idea 2. "Technical order presentations were insufficient in some areas." This is a very global statement. One comment refers more to learning the standard toolbar configuration or presentation than it does the actual TO presentation. Another recommends ITI-ALC provide a "bookmark" capability to enable the user to mark a T.O. step and return to it later.

Idea 3. "Problems with reviewing aircraft previous write-ups." This idea centers on using the menu selection for "O-level history" on the aircraft. The menu items were

not intuitive to the user. Another comment suggested to eliminate the need to go to the menu for the history because of the confusion.

Idea 4. "Change display of aircraft operation status." This idea suggests a single line that is appropriately filled as work is completed on the aircraft be used instead of the current method. This proposed method is currently implemented by users and manually tracked on a scheduling board.

Idea 5. "Modify characteristics of aircraft identification." This idea refers to the depot floor screen that allows the aircraft manager to select aircraft. One comment suggests that the prototype be consistent with the number of mouse clicks needed to activate the selection. The remaining comments suggest capabilities or information that should be added to that screen.

Idea 6. "Master schedule..bar graph colors need to be explained. Ex. red-behind schedule." The users agreed that a legend be implemented to identify what the colors mean on the master schedule.

Idea 7. "Get ready to do maintenance." This covers a functional term referring to the process of making sure the user has the parts and tools needed to perform a maintenance task. These items are located under the main menu item "Prepare for maintenance." The comments listed under this idea deal with fields in screens below sub-menu item "supp equip status" and "kit status."

Idea 8. "Planning interface requirement needed." This idea suggests interfaces be included for planning purposes that currently do not exist. The comments on this idea are very well explained in Table 1.

Idea 9. "Mechanic should be able to return to any technical order task when documenting maintenance performed." Currently the user is unable to go back to a T.O. step once he has completed the maintenance task and began to document the action. This may be necessary in order to accurately document the task and is not currently available.

Idea 10. "Group pertinent aircraft write-ups with work areas." This idea is suggesting to sort the write-ups for an aircraft, so that only those of concern to a specific work area are presented. This eliminates the need to search through all the write-ups to find those that are applicable to a specific work center.

Idea 11. "173 cards need to be shown on the screen with specific number of personnel required." This idea suggests that the number of people performing the inspection documented on the 173 card should not be a choice, but rather predetermined. Tasks that require critical inspection codes need 2 inspectors' signatures, while non-critical inspection coded tasks require only one inspector signature.

Idea 12. "Add fields in support equipment screen." This idea suggests adding fields for part number, federal stock number and nomenclature to the support equipment status screen that is located under menu item "Prepare for Maintenance."

Idea 13. "Capability to reinitiate technical order alerts while performing maintenance." The user is suggesting they be able to reinitiate an active alert from both the menu and the icon.

Idea 14. "Screen showing age equipment backordered was unclear." The context of what the backordered statement was stating can be misunderstood. Terminology should be clearer.

Idea 15. "How to close out was not clear from task to task." The file menu function to log out of the system was not clear to the user. Users suggested that a separate button be created to make logging out faster and easier.

Idea 16. "How to make a mechanic assignment was confusing." The user was unaware that double clicking on the mechanic's name would initiate the assignment screen.

Idea 17. "The logon graphics were great!." The bit map of the aircraft flying across the screen was appealing to the users.

Idea 18. "Process was excellent." The user appeared to think that the scenario that they used when evaluating the prototype was an accurate depiction of the depot process.

<u>Evaluation step 2:</u>

In step 2 of the evaluation, each user rated the importance of the ideas using a 10 point scale. The ideas most critical to the ITI-ALC system were rated a 10 and the least critical ideas were rated at 1. Table 1 ideas are listed as ordered by the users. The most critical idea is listed at the beginning table and the least critical is listed at the end. Details such as number of users selecting a specific rating, the group mean and group standard deviations for each idea are shown in Appendix E.

<u>Evaluation step 3:</u>

In step three of the evaluation, users placed the rated ideas into categories. The predetermined categories were user expectation, screen, navigation, terminology, errors, learning, system capability, and miscellaneous. The purpose of placing the ideas into

categories was to relate each idea back to the questionnaire and the usability measurements. Unfortunately, this did not work well. The ideas generated by the users were functionally oriented as opposed to human factors oriented toward presentation or style issues. In this case, the ideas were directed toward performing maintenance. This made it difficult for the users to place the ideas into human factors categories simply because they were not as familiar with them. To compound the problem, the categorizing was performed at the end of the work day and the users were eager to complete the study and retire. As a result, the categories that the users placed the ideas in did not provide valuable information for supporting ITI-ALC design activities and were eliminated from this chapter. The information from the original categorizing process is contained in Appendix F. It shows all ideas and supporting comments placed within the defined categories as determined by the users.

Usability Questionaire Results

The second instrument used to collect data was the usability questionnaire. The questions and results are separated into three different tables. Separating the information should to make it easier to read and identify pertinent information. The 10 point scale questions are in Table 2. The numbers to the right of the questions indicate the number of users that made a particular response. It should be noted that the median for this scale used in this questionnaire is 5.5. Responses above the median are considered positive responses and those below are considered negative responses. The open end questions are located in Table 3 and the 5 point agree/disagree questions are in Table 4.

Each question and the results for that question are presented immediately following the questionnaire tables. Histograms for the response to the scaled questions as well as the original comments the open end questions are in Appendix G.

The histograms provide a very good graphical presentation of the user responses. They also provide a better picture of the magnitude and spread of the responses made by the users.

Table 2. Usability questionnaire 10 point scaled questions

Usability Questionnaire 10 Point scale questions												
Questions	Lower range	Number of users responding to scale value										Upper Range
		1	2	3	4	5	6	7	8	9	10	
1. Overall, use of the system was	Frustrating				1	1	2	2	1			Satisfying
2. Overall, use of the system was	Difficult				1	1	4	1				Easy
3. The needs of both experienced and inexperienced users were considered	Never				2	2	1	1		1		Always
4. The characters on the computer screen were	Hard to read			1			2	1	1		2	Easy to read
5. The sequence of information on the screen was	Disorganized					1	1	3		1	1	Organized
6. Logging into the system and starting the task was	Difficult					1	1	2	2	1		Easy
7. Navigation among items (e.g., fill-ins) on the screen was	Illogical						4	3				Logical
8. Instructions on how to navigate from screen to screen was	Not helpful	1			2	1	3					Helpful
9. The sequence of flow from one screen to the next was	Illogical							6	1			Logical
10. Logging off the system was	Difficult					2			3		2	Easy
11. The terminology used throughout the system was	Hard to understand					1	1	2	2		1	Easy to understand
12. In relation to the work you do, the use of terminology was	Inconsistent					1	2	1	3			Consistent
13. The terminology used in messages was	Difficult					1	1	4	1			Helpful
14. Correcting mistakes was	Difficult				1	1			4	1		Easy
15. The number of ITI-ALC system failures encountered was			1	2	1	1						
16. Number of error messages encountered was		1	2			2		1				
17. Recovering from errors was	Difficult	1		2		1	1	1				Easy
18. Learning how to use the system was	Difficult		1				3	1	1			Easy
19. Remembering the names and use of commands was	Difficult						1	3	3			Easy
20. Exploration of system functions was	Rigid					1	2	1	1		2	Flexible
21. The task flow between the real world and the system seemed to be the	Different			1	1			2	1	1	1	Same
22. Response time from the system was	Slow							2	3	2		Fast
23. Overall, the system was	Unreliable							1	5		1	Reliable

Table 3. Usability questionnaire open ended questions

Usability Questionnaire Open-end questions	
Questions	Responses
24. What did you particularly like about ITI-ALC?	1. My grand kids will love it 2. Working process 3. It gives basically all information that is needed to accomplish a work task. 4. Something to help mech. 5. Overall sequence was great. flowing from one step to another, fairly easy with minor problems. 6. Flow of work process. easier to track work and parts 7. Step by procedure
25. What in particular did you NOT like about ITI-ALC?	1. I will be dead before I get to use it 2. No instructions up front to navigate. 3. Nothing 4. Some commands were a little misleading. some steps hard to follow. Not enough information on views of work areas. 5. Overall system needs to be more user friendly. More T.O. information needs to be installed. 6. Nothing
26. What recommendations would you make for improving ITI-ALC?	1. Try to make it more user friendly 2. Need more schooling on computer systems 3. Make it more user friendly. 4. Have a few more studies 5. Provide user friendly computer classes to ensure continuity between operators. 6. More input from mechanics. 7. Have a presentation on basic computer skills

Table 4. Usability questionnaire 5 point scale questions

Usability Questionnaire 5 Point scale questions					
Questions	Number of users responding to scale value				
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
27. I would use a Group Support System to evaluating another prototype.	5	2			
28. The GSS helped me to evaluate the rapid prototype faster than if I didn't use it.	4	3			
29. The GSS was effective in helping me evaluate the rapid prototype.	4	3			

Question 1. "Overall, use of the system was:" The range of the answers was from frustrating (1) to satisfying (10). The results show an overall positive tendency with a cluster around the mid-range. Two of the seven users assigned ratings below 5.5 that is a negative rating.

Question 2. "Overall, use of the system was." The range of the answers was from difficult (1) to easy (10). The results show an overall positive tendency with a cluster around the mid-range. Four users assigned a 6 rating with two below 5.5.

Question 3. "The needs of both experienced and inexperienced users were considered:" Possible answers ranged from "never" (1) to "always" (10). Responses to this question are varied with no real tendency being apparent.

Question 4. "The characters on the computer screen were:" The answers range from "hard to read" (1) to "easy to read" (10). The responses range mostly across the positive side of the scale. All but one response to this question was positive.

Question 5. "The sequence of information the screen was:" The answers range from "disorganized" (1) to "organized" (10). . The results show an overall positive tendency with two clusters. The first is at the high range and the second is at the mid-range. Only one response was negative.

Question 6. "Logging into the system and starting the task was:" Possible answers ranged from "difficult" (1) to " easy" (10).). The results show an overall positive tendency with a clustering in the positive range. Only one response was negative.

Question 7. "Navigation among item (e.g., fill-ins) on the screen was:" The answers range from "illogical" (1) to "logical" (10). The results show all responses were positive and were rated either 6 or 7 on the scale.

Question 8. "Instructions on how to navigate from screen to screen was:" The answers range from "not helpful" (1) to "helpful" (10). The results show an overall negative tendency with a cluster around the mid-range. One user rated the navigation at a 1.

Question 9. "The sequence of flow from one screen to the next was:" The answers range from "illogical" (1) to "logical" (10). The results show an overall positive tendency with all responses being 7 or 8. All but one response was rated 7.

Question 10. "Logging off the system was:" The answers range from "difficult" (1) to "easy" (10). Responses showed no clustering. Five of the seven responses were positive with 2 being rated in the negative range.

Question 11. "The terminology used throughout the system was:" The answers range from "hard to understand" (1) to "easy to understand" (10). The results show an overall positive tendency with a cluster around the mid-range. One rating was a 10 and one fell negative

Question 12. "In relation to the work you do, the use of terminology was:" The answers range from "inconsistent" (1) to "consistent" (10). The results show an overall positive tendency with a cluster around the mid-range. Only one response is in the negative range.

Question 13. "The terminology used in messages was:" The answers range from "not helpful" (1) to "helpful" (10). The results show an overall positive tendency with a cluster around the mid-range. Four of the seven users rated a 7 for the message terminology.

Question 14. "Correcting mistakes was:" The answers range from "difficult" (1) to "easy" (10). The results show a split between positive and negative ratings. However, five of the seven users indicated a positive response with two indicating a negative response.

Question 15. "The number of ITI-ALC system failures encountered was:" The results show a clustering at the lower part of the scale. Note that for this question, the response is positive.

Question 16. "Number of error messages encountered was:" The results vary across the scale and show no tendency.

Question 17. "Recovering from errors was:" The answers range from "difficult" (1) to "easy" (10). The results vary greatly across the scale ranging from 1 to 7. No tangible results can be seen.

Question 18. "Learning how to use the system was:" The answers range from "difficult" (1) to "easy" (10). The results show and overall positive tendency. Six of the seven responses are positive.

Question 19. "Remembering the names and use of commands was:" The answers range from "difficult" (1) to "easy" (10). All responses are positive. One response is rated a 6 with the remaining evenly split among 7 and 8.

Question 20. "Exploration of system functions was:" The answers range from "rigid" (1) to "flexible" (10). All but one response is positive. Those positive responses vary relatively evenly across the positive half of the scale.

Question 21. "The task flow between the real worked and the system seemed to be the:" The answers range from "different" (1) to "same" (10). The results show an overall positive tendency with two responses being negative. The positive responses are evenly distributed from 7 to 10.

Question 22. "Response time from the system was:" The answers range from "slow" (1) to "fast" (10). All responses are positive and rated at 7, 8, or 9.

Question 23. "Overall, use of the system was:" The answers range from "unreliable" (1) to "reliable" (10). All responses were positive with five responses being rated 8.

Question 24. "What did you particularly like about ITI-ALC?" Two comments identified positive reaction to the system providing the information needed by the mechanic. Four responses addressed the flow of information. The first being that a system such as ITI-ALC would make it easier to track work and parts. The second indicated the flow of information as he went through the prototype was "fairly easy with minor problems. The third and fourth responses dealing with the flow of information were unclear to exactly what they were trying to say. The last users comment indicated that "his grand kids will love it." The exact meaning to this response could take several avenues, but is taken as being a positive reaction to the prototype.

Question 25. "What did you particularly NOT like about ITI-ALC?" Three comments dealt with the user interface. The first comment suggested that it needed to be more user friendly. The second comment said that some commands were a little misleading. The third indicated that some T.O. steps were hard to follow with not enough information being provided to make instructions clear. Two more responses said there was nothing they disliked about the ITI-ALC prototype and the last suggested that he would be dead before he would get to use it.

Question 26. "What recommendations would you make for improving ITI-ALC?" This question was asked to obtain recommendations from the depot user on what they thought would improve ITI-ALC system. Two users suggested that more studies should be conducted on the system with even more input coming from the mechanic. Two other responses suggested that the system should be made more user friendly, but made no specific suggestions on what would make the system more user friendly. The three

remaining user comments dealt with receiving training on how to use computers and the system.

Question 27. "I would use a Group Support System to evaluate another prototype." All responses were either agree or strongly agree.

Question 28. "The Group Support System helped me to evaluate the rapid prototype faster than if I didn't use it." All responses were either agree or strongly agree that the. prototype was faster than if they did not use it.

Question 29. "The Group Support System was effective in helping me evaluate the rapid prototype." Again, all responses were either agree or strongly agree.

Observation Results

The third method of gathering data was to observe the users and write down observations during the study. During the prototype evaluation, researchers from Armstrong Laboratory assisted in monitoring the users as they evaluated the prototype. The researchers were both familiar with the ITI-ALC prototype and well versed in gathering user feedback for developmental information systems. The compiled notes identify areas where the users were having trouble on a given screen. Researchers also assisted the users in "getting back on track" within the scenario when they became excessively confused on what to do next. The notes were documented in packages showing each screen in the same sequence as the user's evaluation scenario. The individual notes were later consolidated into one package shown in Appendix H. The notes indicate 63 observations were made by the researchers while the users evaluated the prototype.

Analysis

The study provided data relevant to the 4 investigative questions that were identified in chapter 1 of this thesis. Each will be addressed in turn in the following paragraphs.

Invesigative question 1

To what extent has the current prototype adequately captured the user requirements for managing programmed depot maintenance and for performing a depot maintenance task?

Investigative question 1 required the use of both instruments and the observation notes. The first instrument was the GSS gathered ideas and comments. The second instrument was 26 questions from the usability questionnaire. The third form of information was the researcher observation notes.

The results of the GSS ideas and comments are shown in Table 1 of the GSS results. The questions in the usability questionnaire that contribute information to answering this investigative question are 1-26. Histogram for each question is in Appendix G.

User expectations of the prototype. The questions pertaining to the collection of the user expectations of the prototype are as follows:

Question 1. "Overall, use of the system was:" The results show an overall positive tendency toward satisfying, with a cluster around the mid-range.

Question 2 "Overall, use of the system was." The results show an overall positive tendency toward easy to use with a cluster around the mid-range with four responses rated 6.

Question 3. "The needs of both experienced and inexperienced user was considered:" Responses varied with no real tendency being apparent.

Screen organization. The questions pertaining to the screen organization of the prototype are as follows:

Question 4. "The characters on the computer screen were:" Responses range mostly across the positive side of the scale. All but one response to this question was positive.

Question 5. "The sequence of information the screen was:" Results show an overall positive tendency with two clusters. The first is at the high range and the second is at the mid-range. Only one response was negative.

Navigation. The questions pertaining to the navigational ease of the prototype are as follows:

Question 6. "Logging into the system and starting the task was:" Results show an overall positive tendency with a clustering in the positive range. Only one response was negative.

Question 7. "Navigation among item (e.g., fill-ins) on the screen was:" Results show all responses were positive and were rated either 6 or 7 on the scale.

Question 8. "Instructions on how to navigate from screen to screen was:" Results show an overall negative tendency with a cluster around the mid-range. One user rated the navigation at a 1.

Question 9. "The sequence of flow from one screen to the next was:" Results show an overall positive tendency with all responses being 7 or 8. All but one response was rated 7.

Question 10. "Logging off the system was:" Five responses were positive to this question.

Terminology. The questions pertaining to the adequacy of the terminology used in the prototype are as follows:

Question 11. "The terminology used throughout the system was:" Results show an overall positive tendency with a cluster around the mid-range. One rating was a 10 and one fell negative

Question 12. "In relation to the work you do, the use of terminology was:" Results show an overall positive tendency with a cluster around the mid-range. Only one response is in the negative range.

Question 13. "The terminology used in messages was:" Results show an overall positive tendency with a cluster around the mid-range. Four of the seven users rated a 7 for the message terminology.

Minimize potential error. The questions pertaining to the prototype's tendency to minimize potential errors when using it are as follows:

Question 14. "Correcting mistakes was:" Results show an unequal split between positive and negative ratings. Five users indicated a positive response with two indicating a negative response.

Question 15. "The number of ITI-ALC system failures encountered was:" The results show a clustering at the lower part of the scale. Note that for this question, this is within the positive range.

Question 16. "Number of error messages encountered was:" The results vary across the scale and show no tendency.

Question 17. "Recovering from errors was:" Results vary greatly across the scale ranging from 1 to 7. No tangible patterns can be seen.

Learning. The questions pertaining to the ease of learning how to use the prototype are as follows:

Question 18. "Learning how to use the system was:" Results show and overall positive tendency. Six responses are positive.

Question 19. "Remembering the names and use of commands was:" All responses are positive. One response is rated a 6 with the remaining evenly split among 7 and 8.

Question 20. "Exploration of system functions was:" All but one response is positive. The responses vary relatively evenly across the positive half of the scale.

Question 21. "The task flow between the real worked and the system seemed to be the:" Results show an overall positive tendency with two negative responses. The positive responses are evenly distributed from 7 to 10.

Prototype Capabilities.. The questions pertaining to the system capabilities of the prototype are as follows:

Question 22. "Response time from the system was:" All responses are positive and rated at 7, 8, or 9.

Question 23. "Overall, use of the system was." All responses were positive toward the system being reliable with five responses being rated 8.

ITI-ALC open end questions. Specific open end questions pertaining to the ITI-ALC prototype are as follows:

Question 24. "What did you particularly like about ITI-ALC?" This question specifically addresses those aspects of the prototype that stood out and were appealing to the users. Two comments identified positive reaction to the system providing the information needed by the mechanic. Four responses addressed the flow of information. The first being that a system such as ITI-ALC would make it easier to track work and parts. The second indicated the flow of information as he went through the prototype was "fairly easy with minor problems." The third and fourth responses dealing with the flow of information were unclear to exactly what they were trying to say. The last users comment indicated that "his grand kids will love it." The exact meaning to this response could take several avenues, but is taken as being a positive reaction to the prototype.

Question 25. "What did you particularly NOT like about ITI-ALC?" This question specifically addresses those aspects of the prototype that are disliked by the users. Three comments dealt with the user interface. The first comment suggested that it needed to be more user friendly. The second comment said that some commands were a

little misleading. The third comment indicated that some T.O. Steps were hard to follow with not enough information being provided to make instructions clear. Two more responses said there was nothing they disliked about the ITI-ALC prototype and the last suggested that he would be dead before he would get to use it.

Question 26. "What recommendations would you make for improving ITI-ALC?" This question seeks insight into the overall evaluation of prototype. Two users suggested that more studies should be conducted on the system with even more input coming from the mechanic. Two other responses suggested that the system should be made more user friendly, but made no specific suggestions on what would make the system more user friendly. The three remaining users comments dealt with receiving training on how to use computers and the system.

Observations noted on the interaction of the users with the prototype also contributed information to investigative question 1. The observations provided details to identify specific items on the screens that created confusion or problems. Nothing was identified as a major inhibitor for the prototype. The observations in general, support the information gathered by the GSS and the usability questionnaire. In addition, it provides the specific location of many of the problems.

<u>Invesigative question 2</u>

If the prototype does not meet the users needs, what changes or modifications need to be made to correct the prototype system so that it does?

Investigative question 2 is a logical follow on of investigative question 1. It identifies the deficiencies that make the prototype not completely meet the users needs.

As in investigative question 1, investigative question 2 requires the use of all three of the data collection methods: the GSS, the usability questionnaire, and the researcher observations.

The GSS provided the majority of results for answering investigative question 2. These results were summarized in Table 1 and further explained in the section that followed.

The usability questionnaire provides information that identifies general areas of the prototype that could be improved in the interface development. The information is not as specific, but does describe the general impression of the users and identifies those areas where specific problems were not addressed in the other two data collection methods.

The information obtained through researcher observation also identify areas for improvement. Much of the information was a duplication of that identified using the GSS. The ideas that did not duplicate the those gathered with the GSS are shown in Table 5 and should be included with the GSS information to create the complete list of suggested changes.

Table 5. Observations not documented in GSS

Researcher Documented Information not collected in GSS
Meaning of status--wasn't sure if it meant completion or not
Drop Menu for login name--immediately provide list of names
Double click hides schedule--A general problem Min/Max without exec. commands
Step check boxes capability not there--"Double clicked several times" Prototype limit
Wants previous write-ups to come up automatically when receiving the job
Unclear exactly when you are ready to start a task
Screens with o action--no one knows where to proceed unless directed to on screen
Should say whether or not a job is supportable or give reasons--also give delay times
Need status of ordered parts/equipment or task can't be done

Table 5. Observations not documented in GSS (Continued)

"173 card" not labeled--caused participant to search in menu for the 173 card
Difficulty with mechanic list box
"Back" label on locator and Full Screen may be confusing
Master schedule w/Work operation completion notice should be the model for screens

Investigative question 3.

Does the ITI-ALC system present a "Value-added" to the user?

To address this investigative question, the result obtained on questions 1,2, and 24 of the usability questionnaire are revisited. To reiterate, questions 1 and 2 both received positive responses. Question 24 solicits what was particularly liked about the prototype. The results are as follows: Two comments identified positive reaction to the system providing the information needed by the mechanic. Four responses addressed the flow of information. The first was that a system such as ITI-ALC would make it easier to track work and parts. The second indicated the flow of information as he went through the prototype was "fairly easy with minor problems. The third and fourth responses dealing with the flow of information were unclear to exactly what they were trying to say. The last users comment indicated that "his grand kids will love it." The exact meaning to this response could take several avenues, but is taken as being a positive reaction to the prototype.

Investigative question 4.

Does using a group support system aid in prototype analysis?

This investigative question seeks to find out if using the GSS was efficient, effective, and would the users use it to perform an evaluation such as this again. Three

questions on the usability questionnaire address this issue. The responses to these questions are shown in Table 3. Questions 27, 28, and 29 used a 5 point agree/disagree scale to gather user responses. A value of 1 was assigned to the strongly disagree response and a value of 5 was assigned to the strongly agree response with the corresponding integer values being assigned to those responses falling in between. The value assignment allowed weighted averages to be calculated which could be used to obtain the mean and the standard deviation for the group.

Question 27. "I would use a Group Support System to evaluate another prototype." All responses were either agree or strongly agree.

Question 28. "The Group Support System helped me to evaluate the rapid prototype faster than if I didn't use it." All responses were either agree or strongly agree that the prototype was evaluated faster than if they did not use it.

Question 29. "The Group Support System was effective in helping me evaluate the rapid prototype." Again, all responses were either agree or strongly agree.

The researcher observations contribute information that can be used to answer this investigative question. The researcher observations provided a good cross checks as well as an alternate source of information.

Consolidated notes identified 63 observations (Appendix H). Of the 63 observations, 9 were also collected by the users using the GSS. Thirteen more observations were not documented while using the GSS These 13 observation are listed in Table 5. Researcher observations also identified twenty more areas where lack of training on the prototype created problems. These twenty are not necessarily considered

functions or capability of the prototype. Of these 20 training areas, 16 were not previously identified by users in the GSS.

Summary

Three forms of data were collected for this study: group prototype evaluation results, individual prototype usability results, and observations on user-prototype interaction. Seven users consisting of programmed depot maintenance (PDM) technicians and functional supervisors were asked to evaluate the ITI-ALC prototype.

GSS results show that 18 ideas were collected. Sixteen of these were suggested changes or modifications and 2 were positive comments about the prototype opening screen and the task scenario itself.

The usability questionnaire consisted of 29 questions that addressed different aspects of the prototype usability, the general impression of ITI-ALC as portrayed by the rapid prototype, and using a GSS while performing the evaluation. Twenty three of these questions pertained to the usability of the prototype. There were 19 questions with generally positive responses, one with a generally negative response, and three questions that the responses did not give any tendencies either positive or negative. Collectively, responses indicate that the prototype usability was an 83% positive and 4% negative as evaluated by the users in this study. Three open end questions addressed the likes and dislikes of ITI-ALC as a potential depot information system. The aspects ITI-ALC that the users liked was the information that it provided to the mechanic and that it seemed to enhance the information flow in the depot process. Dislikes of ITI-ALC indicate three of the users did not like certain aspects of the user interface, but two indicated that they

found nothing that they disliked about ITI-ALC. Observations of the interaction of the users with the prototype totaled 63. Nine were duplications of information collected using the GSS and thirteen were unique to this method of data collection. Twenty observations could be attributed to lack of training of the prototype. The remaining observations fell into no distinct category and are considered as general comments.

Investigative questions 1 and 2 are addressed by using all the ideas generated using the GSS, the first 26 question asked in the usability questionnaire and selected noted observations. Investigative question 3 is addressed by using the responses from three of the questions in the usability questionnaire and selected observations. All three yielded generally positive responses. Question 4 was addressed solely by the last three questions of the usability questionnaire. The three questions addressed whether the GSS was efficient, effective, and would the users use the GSS again to perform an evaluation. The responses were very positive to each question.

Each investigative question was addressed with the information found pertinent from each data collection method. A discussion of the findings will follow in chapter 5 of this thesis.

V. Discussion, Recommendations, and Conclusions

Chapter Overview

This chapter contains a discussion of the results found during this study. The discussion of the data collected addresses the four investigative questions that were previously identified. Limitations of this study are discussed. Recommendations for the improvement of ITI-ALC prototype as well as prototype evaluation using the three data collection methods used in this study are also discussed. Recommendations for further study on the subject and associated topics are presented.

Discussion of Results

The discussion of the results will follow each stated investigation question. Information obtained using each instrument is combined to address the issues of each investigative question.

Investigative question 1

The first investigative question asks, "to what extent has the current prototype adequately captured the user requirements for managing programmed depot maintenance and for performing a depot maintenance task?"

Results of this study indicate that the ITI-ALC prototype adequately captures the users' requirements. The study shows that users found no major requirement oversights in the prototype concerning planning or performing maintenance tasks. The users did however, submit several recommendations to improve the prototype during the evaluation.

Most problems identified in the evaluation appear to indicate that modification of the existing screens or fields within those screens are all that is needed to make them satisfactory. Several problems noted relate to the ability to navigate within the prototype. The majority of the navigation problems identified appear to fall into 3 main categories. The first area is the way the T.O. Graphics are presented in the electronic T.O.'s. The second is the users lack of experience using computers or a Graphical User Interface (GUI). The third is the lack of prior training on using the ITI-ALC prototype. Another problem that seemed to stand out was the users confusion with terminology used in the prototype

Technical Order Graphics. Depot mechanics use diagrams and graphics within T.O.s during maintenance on a regular bases. The evaluation indicated problems with the T.O. Graphics that pointed mostly to the ability for the user to see the whole graphic. For example, the window showing the graphic that is in the lower half of the screen, appeared to be too small. In addition, the scroll bars are meant to allow the user to see a different area of the graphic seemed frustrating to use. Comments were made such as a menu item needs to be developed that allow the exploded view of and item to be created. Specific items pertaining to this are shown in the GSS documentation, the usability questionnaire, and the throughout the observation notes.

Computer experience. Comments made by users during the evaluation indicated they would like more training on computers. An example of the problems experienced by the users was icon recognition. Users did not know that putting the cursor on the icon will give the name of its function. Observations indicated that many of the users were unfamiliar with the standard windows format of the prototype and were hesitant to explore the capabilities and functions. The

users were unfamiliar with how to use the "pop down" menus, edit boxes that appeared confused them, double clicking the mouse was new to them, etc.

ITI-ALC Training. Functions of the ITI-ALC prototype were not intuitively obvious to the users by looking at the menu items of the prototype. As the users proceeded through the prototype evaluation, a learning curve could be seen. For example, most of the users had difficulty logging on to the prototype as a specific user at the beginning of the evaluation. By the last part of the scenario, this problem had been overcome and the users were smoothly logging off and on the prototype. Users also stated that training on how to use the system would be necessary for the success of an ITI-ALC system.

Terminology. Many problems noted in the evaluation of the prototype revealed that a common terminology did not exist between the what the designers used in the prototype menu and what the users expected. While following the scenario, difficulties were encountered by the users because they were searching for a different term within the menu. As a result, confusion was created for the user as to which item to select to perform the requested action. Some users did not draw the parallel meaning between "Logout" and "Sign off" for example. The term O-level was not intuitive to some of the users. Many instances such as these are documented both Table 1 (GSS documented information) and observation notes (Appendix H). Contradictorily, while performing the evaluation, terminology seemed to be a problem, but the terminology was considered positive in the usability analyses questions.

Investigative question 2

Investigative question 2 states that if the prototype does not meet the users needs, what changes or modifications need to be made to correct the prototype system so that it does? As shown above, the prototype does meet user needs, so this question does not need to be addressed. However, the GSS documented information in Table 1 states specifically those items that the users felt needed to be changed to more adequately meet the depot users needs.

The usability questionnaire indicates that the users have an overall positive reaction to the prototype in the areas of expectation, screen organization, navigation, terminology use, minimizing potential errors, learning, and the prototype capabilities. A specific area that was identified as having a negative reaction by the group was the prototype's ability to provide instruction on how to navigate from screen to screen. Details that support this result are identified in the GSS Table 1 and throughout the researcher observation notes. Questions 25 and 26 of the questionnaire specifically ask for what the users did not like about the prototype and the recommendations they had for improving the prototype, respectively. Users said that designers should try to make the prototype more user friendly and menu commands more clear. They also indicated that more graphics such as 3 dimensional or exploded views should be provided of the areas where they are working. Other improvements were to conduct more studies, to continue getting feedback from the mechanics and to provide training for the users on ITI-ALC and the use of computers in general.

Table 5 lists 13 researcher notes on areas for improving the prototype. Substantial information can also be gleaned by reviewing the observational notes for improving the ITI-ALC prototype.

Investigative question 3

Investigative question 3 asks, "does the ITI-ALC system present a "Value-added" to the user?" General indications of the results of the study indicate that ITI-ALC is a "Value added" to the user. Questions pertaining to the overall system indicated a positive reaction by the users although not an overwhelming one. Question 24 solicited comments about what the users particularly liked about the prototype. Specific comments from the user on this question indicated that ITI-ALC would provide the information needed by the depot mechanic. They also indicate and that using the system would make it easier to track parts and monitor the depot work on aircraft.

Investigative question 4

Investigative question 4 asks, "does using a Group Support System aid in prototype analysis?"

The findings in this study indicate that using a GSS does support prototype analysis. Results show that all users believe that the GSS was effective and aided in helping to evaluate the prototype faster than if they did not use it. They also unanimously agreed that they would use a GSS to evaluate a prototype again.

Additionally, this study identified areas where the GSS did not support the prototype analysis well. These areas are when the users were unskilled in typing, and when problems were

difficult for the users to describe in words or they did not realize that a problem existed. Specific items that were not documented using the GSS but were identified by one-on-one researcher and user interaction are in Table 5.

Typing skill. This researcher's observations were that skilled typing users, appeared to use the GSS more to document the findings of the evaluation. When the users were unskilled in typing, they seemed to want to verbalize their problems to the researcher as opposed to typing the problem into the GSS. In many cases they seemed very reluctant to type the information into the GSS, even though they felt the information was valuable. To alleviate this problem, during the brainstorming portion of the evaluation, a more skilled typist would enter the information into the GSS. After such, the user that initiated the idea would confirm that the information was correct.

Documentation difficulties. In some cases, the users had difficulty putting into words the difficulty they were experiencing. In cases such as this, information is most certainly lost when solely using the GSS because the user might elect to not document the problem.

Unaware of problem. In some cases the users did not realize they were having a problem. They seemed to believe that the problem was in their own ability and not in the instructions of the prototype. In situations like this, the GSS would not adequately capture the problems and the use of an observer might be the best way to capture the information.

Limitations of this study

Simulated environment

This is only one study conducted using a prototype. As a simulation with a prototype, it may not totally match the experience of real work with an operational system. The laboratory environment controls many of the elements that can effect an operation system. The closer to the actual environment the more realistic the test is and therefore the better the results are.

Computer and typing skills. Two of the largest limitations of this study were the effects that limited computer experience and lack of typing skills had on using the GSS. The pairing of these two limitations may have limited the number of ideas generated during evaluation of the prototype for some users. It also served to extend the time required by some to perform the evaluation and complete the associated questionnaires. The frustration this created for the users could possibly have inhibited the perceived effectiveness of the GSS in the prototype evaluation. When dealing with users that are very comfortable using computers and associated software, the GSS can be a tremendous asset. When this capability does not exist, or is limited, the one-on-one approach of prototype evaluation is, in this researcher's opinion, the preferred evaluation method.

GSS Laboratory. Another limitation of this study was the size and environmental conditions of the room where the prototype evaluation took place. The room dimensions were small and limited the "elbow room" that each user had to work. Compounding this limitation was that the air conditioning in the building was not working properly, making the room uncomfortable to work in for an extended period of time. The combining of these two limitations along with the extra time required to conduct the evaluation because of limited

computer and typing skill, undoubtedly had a negative effect on the volume of ideas as compared to if these limitations did not exist.

Recommendations for Further Research

Two areas for further research have been identified from this study. The first is to make the suggested changes in the ITI-ALC prototype and conduct further studies and evaluations. The second is to initiate further research into using a GSS to perform prototype analysis.

More research on the ITI-ALC prototype should be conducted before the final demonstration system configuration is decided. "It is impossible to develop a solution to solve a design problem in a single iteration" (Gould & Lewis, 1985:302). Further study should identify other avenues to further improve and refine the ITI-ALC system. The iterative process of developing and testing the prototype has proven to be winning approach for Armstrong Laboratory and continuation of this approach is warranted. The suggested changes put forth by the users should be reviewed as well as the data collected during the study that does not identify specific changes. This may facilitate more changes that will be beneficial to the ITI-ALC demonstration system. After changes have been made to the prototype, one to two more evaluations should be conducted before establishing the demonstration system final design.

Modifications to the current user centered workshop plan should include a better assessment of the user's computer skills and the modification or elimination of pre-determined human factors categories used in the evaluation.

Pre-determined categories during prototype evaluation can be beneficial when the terms and categories are understood by all that are using them. When they are not, it can be a source of confusion and the results may be disappointing. Whether or not to use pre-determined human factors categories should be dictated by users performing the evaluation.

Research should be conducted to determine more specifically the benefits of using a GSS to facilitate the evaluation of prototypes. Guidelines for when to use a GSS for prototype analysis should also be developed. A GSS according to the findings of this study can be a help in prototype evaluations. A study should also be conducted to perform a direct comparison between using a GSS to perform a prototype analysis and using the one-on-one approach typically adopted.

Conclusions

The ITI-ALC rapid prototype appears to functionally meet the requirements of the users and it does present "value added" information. Several suggestions however, were proposed by the users performing the evaluation. The suggested modification or changes generated by the users will help improve the prototype, and as a result, gain more user acceptance. According to Nielson and Levy, user feedback and opinions are valuable data that should be used in the development or choosing of a user interface design. The user interface of a system or software package has a very good chance of being successful if it agrees with the interface opinions of the users (Nielson and Levy, 1994).

Results of this study also indicate that a GSS is useful in performing prototype analysis. Users found that the GSS was both effective and efficient to use while performing the prototype

analysis. They also indicated that they would use the GSS again to perform another prototype analysis given the opportunity.

Appendix A: User Centered Workshop Plan

I. User Centered Workshop Plan

Purpose

The objectives of this thesis research are to: (1) perform an assessment of the ITI-ALC rapid prototype and elicit suggestions for changes or modifications, to the current system requirements that are necessary for the initial baseline of the ITI-ALC system, (2) determine the ITI-ALC rapid prototype's compatibility with the user's needs, and (3) investigate the use of group support systems for prototype analysis.

Hardware

The ITI-ALC rapid prototype will be presented on 386SX 25 Mhz computers in the groupware laboratory located in room 319 of building 641, at the Air Force Institute of Technology (AFIT).

Software

The software for this study includes the rapid prototype developed by Armstrong Laboratories using Microsoft Visual Basic 3.0 Professional and Microsoft Access 2.0, and Ventana Group System for Windows that will facilitate evaluation data collection.

Room Equipment

The room will be equipped with 8 users user terminals and 1 facilitator terminal networked together. It will also have an overhead projector equipped with LCD panel for displaying information to the group and two white boards to aid potential group discussions.

Subjects

There will be a total of 7 aircraft programmed depot maintenance (PDM) technicians, functional supervisors or managers for the aircraft depot line at Warner Robins AFB Air Logistics Center. All users will be either currently performing the job they represent, or have recent experience in that position.

Task

Each user will review the ITI-ALC rapid prototype by stepping through an established scenario (Appendix B). Users will be free to converse with each other, if they wish, as they

perform the walkthrough thereby taking advantage of the individual evaluation and group interaction. As user perform the walkthrough, they will document their comments using a group system software. The group system software used for this study is the Ventana GroupSystem for Windows. This software will serve as a tool to collect and present ideas for improving or modifying the rapid prototype. These ideas will subsequently be rated on a scale from 1 to 10 by each individual. The rating results will then be combined, creating an initial ranking of all the group ideas. This experiment will provide valuable feedback on the rapid prototype by providing suggested areas for improving the system's usability and enhancement of the requirements already addressed by the prototype.

Conditions

The rapid prototype will be presented independently on each users terminal. The users, made up of mid-level managers and maintenance technicians from one base, will simultaneously provide comments on the prototype using group software. This simultaneous evaluating of the rapid prototype and documenting the ideas, will be possible by having both programs running and using the "Alt-tab" function to toggle between the two. The group software allows users to document and interactively, yet anonymously, discuss their ideas for improving the rapid prototype. The group software allows each user to view their own ideas, as well as those made by the other users on their own computer terminal or on a separate display overhead, aptly named the "Big Screen".

Projected Study Results

1. Improved understanding of ITI-ALC suitability in satisfying user needs by identifying those rapid prototype features that worked well, and those did not.

2. Feedback from the users in this study will provide insight into the changes that should be made to the evolving design concepts for the ITI-ALC system development and those features which currently meet or exceed user's needs.

3. The ideas collected in this study will made available to Armstrong laboratory to provide to the contractor developing the ITI-ALC demonstration system.

4. This study will illustrate the potential value of groupware in future usability studies.

Data Collected

Demographic data will be collected for each individual using the Personal Background Form (Appendix C). During the evaluation, ideas, comments, categories, and ratings made by the users will be collected using the group software. Evaluator observations in the form of notes and comments on a paper copy of the walkthrough will also be collected during the session. (Appendix H). Data produced by this study include a list of requirements, changes and modifications to be considered for the ITI-ALC system. For each change or modification identified, the users will provide comments and prioritization rating (i.e., how important is the requirement) (Nielson, 1992).

A questionnaire (Appendix D) will be administered at the conclusion of the test to gather any remaining comments or suggestions pertaining to the rapid.

Controls

The goal of this study is to gather uninhibited ideas on a rapid prototype to identify missing requirements and usability problems of the ITI-ALC system prior to its final design. The nature of this study is to therefore have limited controls and to place minimal restrictions on the group. Some controls however are unavoidable in order to maintain the integrity of the results. These controls are as follows:

1. All users will be from one base to eliminate variability in accepted local maintenance operating procedures.
2. The group will walk through a single scenario during the initial evaluation.
3. The Group software laboratory will be isolated from outside activities to keep distractions to a minimum.

II. Workshop Procedures

Introduction

The day's session will begin by introducing the users to the purpose of the study, what the ITI-ALC rapid prototype is, and explaining what their role is in the evaluation. The facilitator, technographer, and other researchers will then be introduced with a short description of their roles. Each user will also introduce themselves and give a description of the job they perform. The logical outcome of the introduction is not merely to introduce the people to each other, but rather to help focus on what the problem at hand is and begin building a comfortable working environment. At the end of the introduction, users will human use and consent form (Appendix I) indicating that they are willing to participate in the evaluation.

Phase I

In Phase I, the users are introduced to the Group System software, which will be the primary tool for gather information. The user are instructed on what the "buckets", "ideas" and "comments" functions of the software are used for. Buckets are the categories that the ideas and comments will be put into during the evaluation. They are typically simply a general heading. Buckets for screen, navigation, terminology, and errors will be created at this time to show the users how to create buckets so that more can be added during the evaluation as they are needed. Ideas in this study, will be the major point or problem that is being identified about some aspect of the prototype. Comments can be considered sub-bullets or text to help clarify the meaning or

provide recommendations for the basic idea. These functions will facilitate the initial information gathering and brainstorming that will generate ideas during this evaluation.

Phase II

After the group software tutorial is performed and the users are comfortable with the Group System software, the group will proceed to the beginning of the evaluation and the walkthrough scenario of the ITI-ALC rapid prototype. To ensure a clear, conceptual understanding of how the prototype scenario will flow, a logic flow chart depicting a typical job assignment through completion will be shown. The group will now begin the walkthrough, ask questions, and in general get a good "feel" for the prototype and its capabilities as well as its functional intent. As the users walkthrough the scenario, the will make comments on the rapid prototype using the group software. Again this action can be performed by using the "Alt-tab" feature. The users will create a list of ideas identifying changes, modification and missing requirements pertaining to the rapid prototype. They will also identify those features of the rapid prototype that they like. These ideas will be presented on the "big screen" as well as the terminal of each user. The facilitator and evaluators from Armstrong laboratory will observe any problems or reactions toward the rapid prototype and document them accordingly. They will also answer questions and provide assistance to the users when needed.

Phase III

Once the all users have completed the walkthrough, and comments have ceased, the group will review as a group the ideas that have been generated. The group will discuss the ideas and comments making additions or modifications as needed. They will also place all the ideas into groups or "Buckets" which identifies the common category that each of the ideas are in. Initially common groups for Screen, Prototype Navigation, Terminology, Errors, and Learning problems, will be established but the group may add any other bucket that they wish to group the ideas as they see fit. At any time, users can refer to the rapid prototype on their individual terminal. They can also request to see a rapid prototype screen, series of screen, or the walkthrough in whole or in part on the big screen The assimilation of free flowing ideas and comments about the prototype will continue. When the input ideas or participation reduces to a level where the session is becoming stagnant, the experimenter will attempt to reinitiate the group interaction. A experimenter will attempt to stimulate discussion in an area that has not received much, if any attention. This process will continue until all ideas and comments are exhausted.

Phase IV

Phase four of the evaluation will be the rating of the ideas by each of the users. To prepare for the rating, all ideas will be flattened. In flattening, all ideas are taken out of the buckets and set so that no one idea is grouped or deemed more important than the other. Now the rating can begin.

In rating, users will have a rating scale to the right of each idea. Each user will rate the idea according to the severity of the problem, 10 being the most severe and 1 being the least severe. When all users are finished rating the ideas, the Group System software will combine each users results into an aggregate ranking. This aggregate ranking will represent the groups ranking of ideas according to their severity. If there is a general consensus, the rating will be complete. If it is not, and some idea ratings appear to be bi-polar, the group will discuss the ideas with the most inconsistency to determine why this might be the case. If for some reason a user wants to change his/her rating, they may modify the individual ratings accordingly.

<u>User Feedback/Wrap-up</u>

At the conclusion of the test, a questionnaire(Appendix D) will be administered to gather any remaining comments or suggestions pertaining to the rapid.

<u>Evaluation measurement</u>

The following information will be used by the experimenter to analyze and draw conclusions in this experiment.

1. A ranked list of ideas identifying potential changes to the rapid prototype.

2. The consolidated ideas will be categorized into groups or areas of concern.

3. Explanatory comments on each idea will help clarify the meaning and provide recommendations on missing human-computer interface or functional requirements.

4. Individual assessment of the prototype as obtained in the usability questionnaire.

III. Conducting the Workshop

Sequence of Events

- Introduction to the experiment
- Background briefing on ITI-ALC
- Completion of the Personal Background Form
- Introduction to the group software
- Rapid prototype walkthrough and initial gathering of ideas
- Group review and brainstorming of ideas and comments
- Consolidating and refining of the group comments
- Voting and rating of the group identified deficiencies by the individual users
- Consolidated rating of the ideas
- Group consensus review of results
- Feedback/Wrap-up

Introduction

The experiment will begin with an introduction of the researchers and their roles. Specifically, to identify the study facilitator, technographer and other researchers that are present. The users will then introduce themselves and identify their jobs or positions. This will serve to identify those participating in the experiment and begin to build group familiarity. The users will next receive a briefings that outline the ITI-ALC program, describing the purpose of the experiment, the way the information will be collected, and preliminary instructions. Preliminary instructions will include the responsibility of the test user, the type of information that will be collected during the experiment, and how the collected data will be used. The users will be reminded that their participation is voluntary and the data collected will not be associated with their name.

Group software tutorial

The users will be introduced to the group software and receive a tutorial on how to use it. This tutorial will encompass the concepts of what buckets, ideas, and comments are and how to create and use them to collect the information on the rapid prototype during this study.

Rapid Prototype Evaluation

The evaluation will begin with the users using a scenario to walkthrough the rapid prototype and use group software to collect all the ideas and comments that are generated.

The users will then transition into a group review and brainstorming session on the rapid prototype deficiencies. In this session, the group will add to, modify, regroup, or delete buckets, ideas, or comments as needed to fully document any concerns about the prototype. The group may refer to the rapid prototype, use the white boards or use any other tool available to achieve their end results.

Now that the comments are refined, they will be removed from their respective categories, and each users will vote on the severity or importance of each noted discrepancy. The group software will be used to consolidate and present the results of the individual ratings. Any discussions and changes to the ratings will be made as a group at this point. The result will be a general group consensus as to the ranking of the discrepancies.

User Feedback/Wrap-up

At the conclusion of the test, a questionnaire will be administered to gather any remaining comments or suggestions pertaining to the rapid.

Appendix B: Rapid Prototype Evaluation Scenario

Task 1

You are the manager of two aircraft. You are in charge of PDM requirements for each of these aircraft from Receiving to Delivery. You need to assign Tim T. Toolman to Replace the FCR Left Equipment Rack Support Assembly on an F-16.

Start

- First, log in as the Aircraft Manager
- Your first screen is the depot floor showing the aircraft that you are in charge of.

Select Aircraft for Maintenance and View Aircraft Schedule

- Go to the schedule for the F-16 that you are in charge of.

Assign Job to Mechanic

- Change the tasking (Replacing the FCR Left Equipment Rack Support Assembly) from Dan Carlson to Tim T. Toolman.

Transmit Assignment Message

- Transmit tasking changes to personnel.
- Sign off as the Aircraft Manager

Task 2

You are a mechanic named Tim T. Toolman and are signing onto the ITI-ALC system for the day. You will need to review any previous write-ups relating to the FCR rack, get ready to do maintenance, and replace the FCR Left Equipment Rack Support Assembly.

Start

- First, log in as the mechanic

Review Job Assignment

- Your first screen is the Work Operations List

Review Previous Write-ups

- Review previous write-ups relating to the FCR Left Equipment Rack Support Assembly

Get Ready to do Maintenance

- Get the technical data for the FCR task (over the RF Modem to your computer)
- Check the availability of AGE for your task
- Check to see if you have all the parts you need to perform the task
- If not, then request the needed parts

Perform Maintenance

- Step through the input conditions for Replacing the FCR Left Equipment Rack Support Assembly.
- Indicate that the removal of the Dual Mode Transmitter has been completed.
- When you get to the *first step* of the task, assume you do not know where this FCR rack is and look at a graphic identifying the access door for this FCR rack.
- Indicate that you've completed the Electrical Surface Bonding Procedures.

- Move to the next series of steps.
  - *At step 3.* In order to display an enlarged view of the rack, find the hot spot on the graphic.
  - *At step 6.* On a graphic, find the indication of the gap.
- Move through the next series of steps
  - Redisplay the Caution and Note for Step 7

<u>Complete Job Documentation</u>

- Move to the Completion Form (Similar to 173 card)
- Assume another mechanic needed help moving a cart sometime during the maintenance process. You lost 15 minutes helping out. Make a note of this delay.
- One person will be required to inspect the replacement
- Click in the signature box (THIS IS A SIMULATION OF SIGNATURES)

<u>Transmit Repair Information</u>

- Notify your manager of job completion
- Assume it is now lunch time. Sign off as the Mechanic

Task 3

You are the Aircraft Manager again. You want to check to see if Tim has completed his work.

Start

- First, log in as the Aircraft Manager

Review Repair Information

- Go to the schedule for the F-16 you are in charge of.
- Check the form Tim filled out
- Look at his Start and Stop times

Revise Schedule

- Revise your maintenance schedule
- Sign off as the Aircraft Manager

Appendix C: Personal Background Form

1. **User Name**________
2. **Check one:**
3.   Military________
4.   Civilian________
5. **Time in Service:** ________ (years/months)
6. **Paygrade:** ________
7. **Current occupational specialty** (job title or AFSC): ________

Prior Work Experience:

	(1)	(2)	(3)
8. Occupational Specialties:	________	________	________
9. Where:	________	________	________
10. Number of years:	________	________	________
11. Dates worked:	________	________	________

Education/Training

12. Education - highest grade completed: ________

Training Courses for occupation

13. Courses:	________	________	________
14. Number of years:	________	________	________
15. Dates worked:	________	________	________

16. Aircraft Depot Experience:____

Computer Experience

17. Indicate models or types of systems used (Mainframe, PC, etc.) and years/months of experience with those systems____

Software use

Example: (word processor, spreadsheet,)(Windows, DOS, Macintosh)______________

____

Appendix D: ITI-ALC Usability Questionnaire

USER EXPECTATIONS

	Frustrating									Satisfying
1. Overall, use of the system was	O	O	O	O	O	O	O	O	O	O
	Difficult									Easy
2. Overall, use of the system was	O	O	O	O	O	O	O	O	O	O
	Never									Always
3. The needs of both experienced and inexperienced users was considered	O	O	O	O	O	O	O	O	O	O

SCREEN

	Hard to read									Easy to read
4 The characters on the computer screen were	O	O	O	O	O	O	O	O	O	O
	Disorganized									Organized
5 The sequence of information on the screen was	O	O	O	O	O	O	O	O	O	O

NAVIGATION

	Difficult									Easy
6. Logging into the system and starting the task was	O	O	O	O	O	O	O	O	O	O
	Illogical									Logical
7. Navigation among items (e.g. fill-ins) on the screen was	O	O	O	O	O	O	O	O	O	O
	Not helpful									Helpful
8. Instructions on how to navigate from screen to screen was	O	O	O	O	O	O	O	O	O	O
	Illogical									Logical
9. The sequence of flow from one screen to the next was	O	O	O	O	O	O	O	O	O	O

	Difficult									Easy
10. Logging off the system was	O	O	O	O	O	O	O	O	O	O

TERMINOLOGY

	Hard to understand					Easy to understand				
11. The terminology used throughout the system was	O	O	O	O	O	O	O	O	O	O
	Inconsistent									Consistent
12. In relation to the work you do, the use of terminology was	O	O	O	O	O	O	O	O	O	O
	Not helpful									Helpful
13. The terminology used in messages was	O	O	O	O	O	O	O	O	O	O

ERRORS

	Difficult									Easy
14. Correcting mistakes was	O	O	O	O	O	O	O	O	O	O
	1	2	3	4	5	6	7	8	9	More
15. The number of ITI-ALC system failures encountered was	O	O	O	O	O	O	O	O	O	O
	1	2	3	4	5	6	7	8	9	More
16. Number of error messages encountered was	O	O	O	O	O	O	O	O	O	O
	Easy									Difficult
17. Recovering from errors was	O	O	O	O	O	O	O	O	O	O

LEARNING

	Easy									Difficult
18. Learning how to use the system was	O	O	O	O	O	O	O	O	O	O
	Difficult									Easy
19. Remembering the names and use of commands was	O	O	O	O	O	O	O	O	O	O
	Rigid									Flexible
20. Exploration of system functions was	O	O	O	O	O	O	O	O	O	O

	Different									Same
21. The task flow between the real world and the system seemed to be the	O	O	O	O	O	O	O	O	O	O

SYSTEM CAPABILITIES

	Slow									Fast
22. Response time from the system was	O	O	O	O	O	O	O	O	O	O
	Unreliable									Reliable
23. Overall, the system was	O	O	O	O	O	O	O	O	O	O

ITI-ALC

24. What did you particularly like about ITI-ALC?

25. What in particular did you NOT like about ITI-ALC?

26. What recommendations would you make for improving ITI-ALC?

GSS

	SA	A	N	D	SD
27. I would use a Group Support System to evaluate another prototype.	O	O	O	O	O
	SA	A	N	D	SD
28. The GSS helped me to evaluate the rapid prototype faster than if I didn't use it.	O	O	O	O	O
	SA	A	N	D	SD
29. The GSS was effective in hlping me evaluate the rapid prototype.	O	O	O	O	O

Appendix E: Idea Voting Results

	Number of Votes in Each Rating									
	10	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
1. T.O. graphics insufficient	3	1	2	1	0	0	0	0	0	0
2. T.O. presentation	3	2	0	2	0	0	0	0	0	0
3. Review previous writeup	2	1	2	2	0	0	0	0	0	0
4. Aircraft operation status	3	0	1	3	0	0	0	0	0	0
5. Aircraft identification	2	2	2	0	0	1	0	0	0	0
6. Bar graph colors need to be explained. ex. red-behind schedule, (legend)	3	0	2	1	0	1	0	0	0	0
7. Get ready to do maintenance	0	0	6	1	0	0	0	0	0	0
8. Planning interface requirement	0	2	3	1	1	0	0	0	0	0
9. Should be able to return to T.O.. task when documenting maint.	1	0	3	3	0	0	0	0	0	0
10. Group write ups with work areas	0	1	3	2	1	0	0	0	0	0
11. 173 cards need to be shown on screen as a number	1	0	3	1	2	0	0	0	0	0
12. Support equipment	0	2	0	3	2	0	0	0	0	0
13. Perform maint	0	1	1	2	1	2	0	0	0	0
14. Age equipment backorder unclear	0	1	0	2	3	0	0	0	0	1
15. Closing out not clear from task to task	0	0	0	2	3	1	1	0	0	0
16. Mechanic assignment	0	1	0	1	1	2	1	0	0	1
17. Logon graphics great!	2	0	0	0	0	2	0	2	0	1
18. Process was excellent	0	1	0	0	2	0	3	0	1	0

Appendix E: Idea Voting Results (Continued)

	Mean	STD	Total	n
1. T.O. graphics insufficient	8.9	1.2	62	7
2. T.O. presentation	8.9	1.4	62	7
3. Review previous write-up	8.4	1.3	59	7
4. Aircraft operation status	8.4	1.5	59	7
5. Aircraft identification	8.4	1.7	59	7
6. Bar graph colors need to be explained. ex. red- behind schedule, (legend)	8.3	1.9	58	7
7. Get ready to do maintenance	7.9	0.4	55	7
8. Planning interface requirement	7.9	1.1	55	7
9. Should be able to return to T.O.. task when documenting maint.	7.9	1.1	55	7
10. Group write ups with work areas	7.6	1	53	7
11. 173 cards need to be shown on screen as a number	7.6	1.4	53	7
12. Support equipment	7.3	1.3	51	7
13. Perform maint	6.7	1.5	47	7
14. Age equipment backorder unclear	6	2.5	42	7
15. Closing out not clear from task to task	5.9	1.1	41	7
16. Mechanic assignment	5.3	2.5	37	7
17. Logon graphics great!	5.3	3.5	37	7
18. Process was excellent	5	2.2	35	7

Appendix F: Categorized Rapid Prototype Evaluation

Appendix F is the product of the original categorization process. It contains the ideas and comments generated by the users placed into predetermined categories. The users, as a group, took the generated ideas and placed them into the categories. Note that the categories are eliminated in table 1 because they did not provide valuable information for the human factors engineers developing ITI-ALC.

USER EXPECTATIONS

1. AIRCRAFT IDENTIFICATION

- are these aircraft tail numbers? which is assigned to me?
  highlighted aircraft signify managers aircraft.

- need bldg location i.e. bldg number and bay

- Selection of aircraft should be consistent with other selections. Single mouse click without watch symbol confusing. Double-clicking caused work form to update.

- identify which aircraft belongs to which aircraft manager. this info would be useful in can items. (read only)

- provide history of aircraft configuration
    - which tctos have been complied with?
    - what special work has been performed?

2. TO Presentation

- need capability to mark last completed step (e.g., bookmark)

- warnings before starting tasks are very helpful.

- to ensure proper recognition of icons computer classes for all mechanics a must.

3. AIRCRAFT OPERATION STATUS

- status bar is difficult to read, would rather see a time line of operation showing completion

4. BAR GRAPH COLORS NEED TO BE EXPLAINED. EX. RED- BEHIND SCHEDULE, (Legend)

5. SUPPORT EQUIPMENT

- need to show part number
- fed. stock number, and nomenclature.

6. TO graphics insufficient

- graphic donest show gap tol.
- picture of rack not sufficient
- graphics should be displayed full view on entry and be able to zoom in on specific areas
- need more than one view on locator area around work needs to be more detailed
- add menu capability for exploded views.

SCREEN

1. CLOSING OUT NOT CLEAR FROM TASK TO TASK

- wording unclear could not find sign off
- have an exit button to log out

2. LOGON GRAPHICS GREAT!

- Aircraft fly-by

3. PERFORM MAINT

- like acft locator
- have capability to reinitiate alert from the menu or icon (step 7).

NAVIGATION

1. MECHANIC ASSIGNMENT

- did not know clicking on mechanic name was way of selecting name

2. PLANNING INTERFACE REQUIREMENT

- need interface with planning organization as with problems in process such as tcto compliance, e.g., cams indicates a tcto being c/w when actually it's not
- need interface with engineering for 202 requests and also afto 22 requests

3. SHOULD BE ABLE TO RETURN TO T.O. TASK WHEN DOCUMENTING MAINT.

TERMINOLOGY

1. REVIEW PREVIOUS WRITE-UP

- needs to be reworded to reflect "previous" in lieu of o level
- how do you get to previous write-ups
- bad menu choice o-level history
- have write ups come up before job is started
- spell out "o level" to organization
- don't abb. menu items

Errors

1. 173 CARDS NEED TO BE SHOWN ON SCREEN AS A NUMBER

- inspection code should be predetermined, not an option. Critical requires 2, noncritical requires 1
- Need to allow one signature box for each person signing the "card."

LEARNING

SYSTEM CAPABILITY

1. GET READY TO DO MAINTENANCE

- need to reflect between age and test equipment
- need further instruction on how to order equipment
- need to show ordering status
- can't perform task unless equipment is available
- on parts source what is none

2. AGE EQUIPMENT BACKORDER UNCLEAR

- has equipment on backorder already been ordered or does mechanic need to order?

3. GROUP WRITE UPS WITH WORK AREAS

- Group tasks by physical location.

MISCELLANEOUS

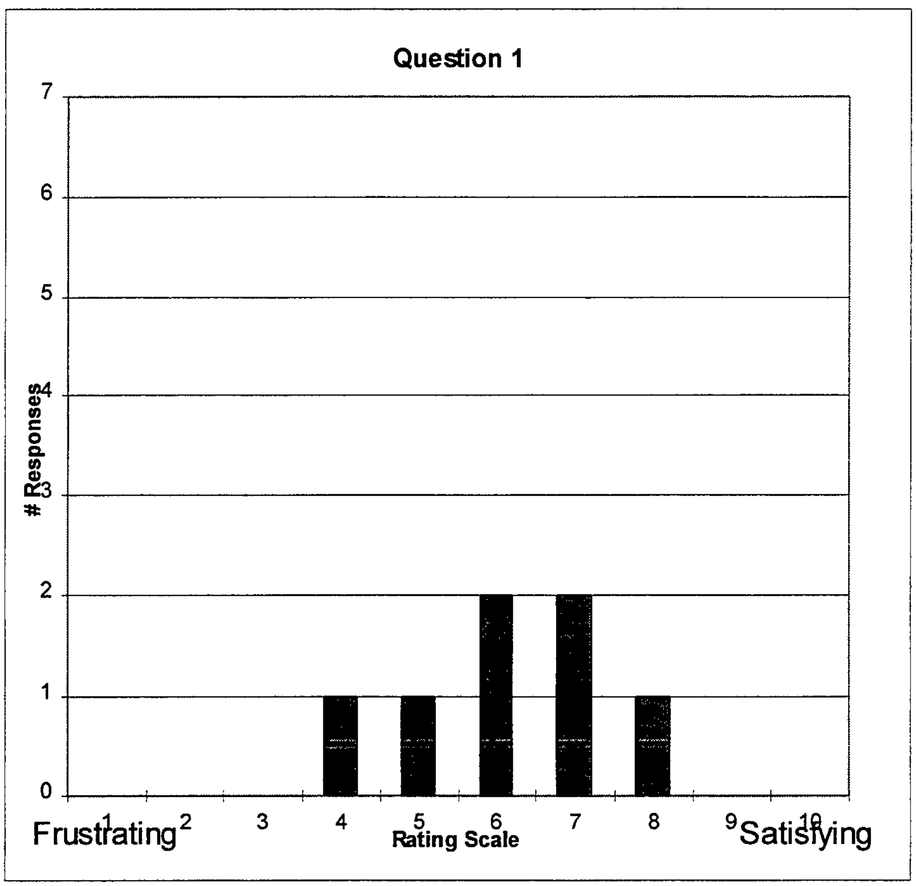
1. PROCESS WAS EXCELLENT

- scenario was excellent

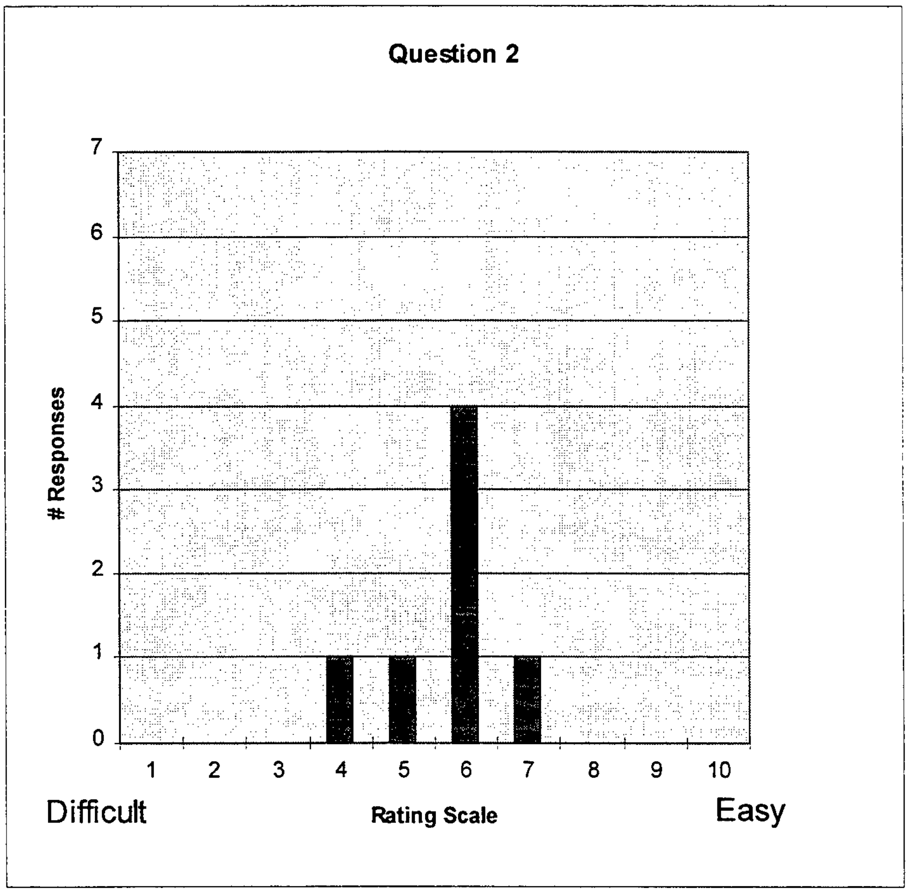
Appendix G: Histograms for the Usability Questionnaire Items

USER EXPECTATIONS

Question 1: Overall, use of the system was <Frustrating (1) to Satisfying 10)>

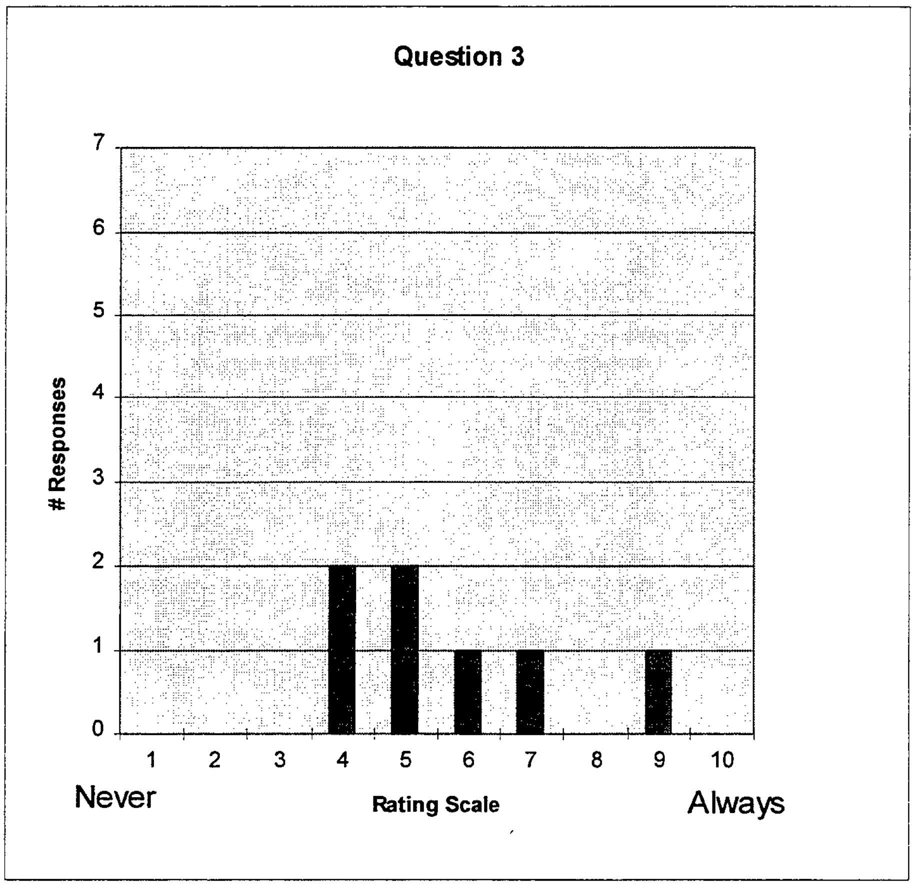


Question 2: Overall, use of the system was <Difficult (1) to Easy (10)>



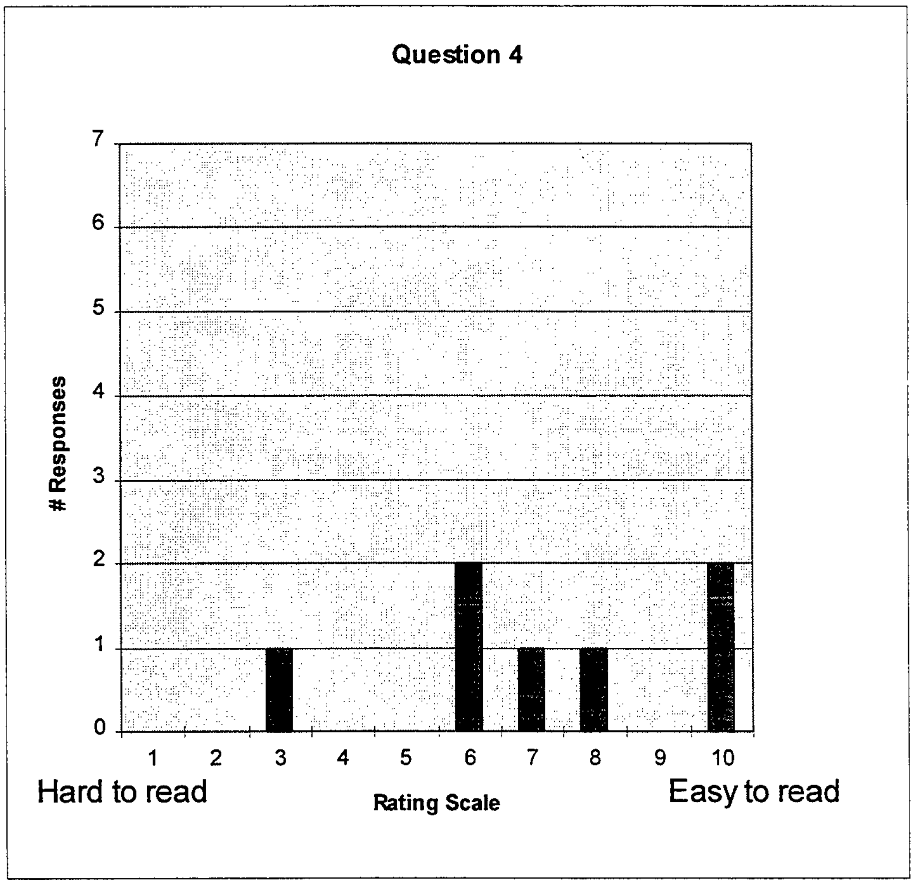
Question 3: The needs of both experienced and inexperienced users was considered

<Never (1) to Always (10)>

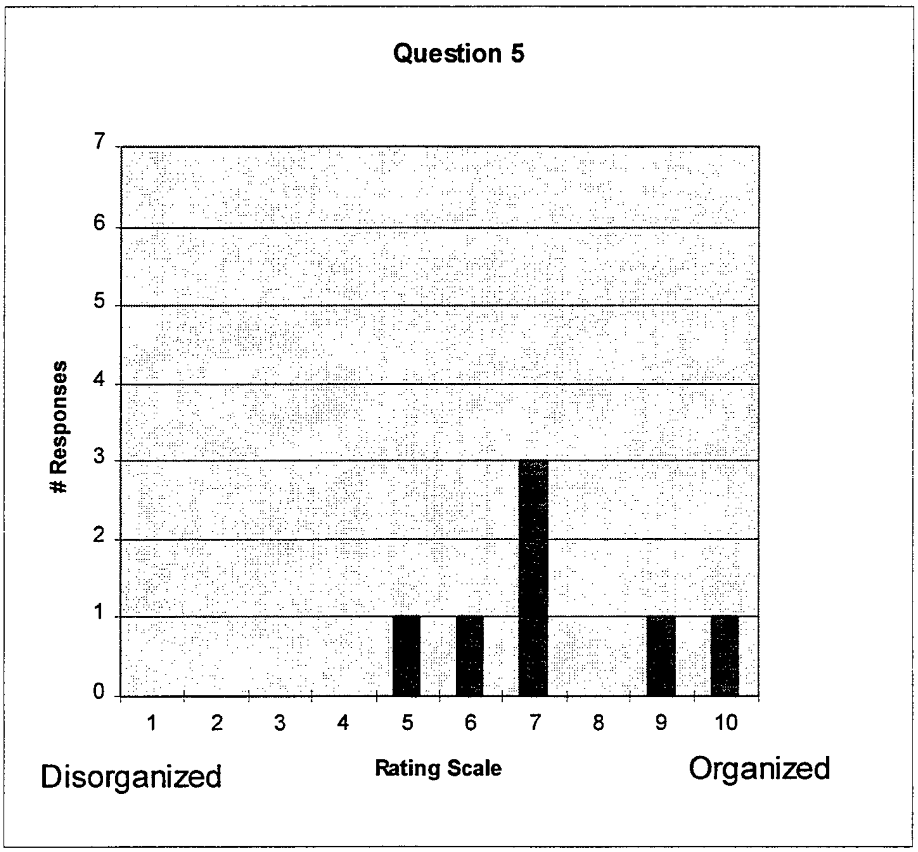


SCREEN

Question 4: The characters on the computer screen were <Hard to read (1) to Easy to read (10)

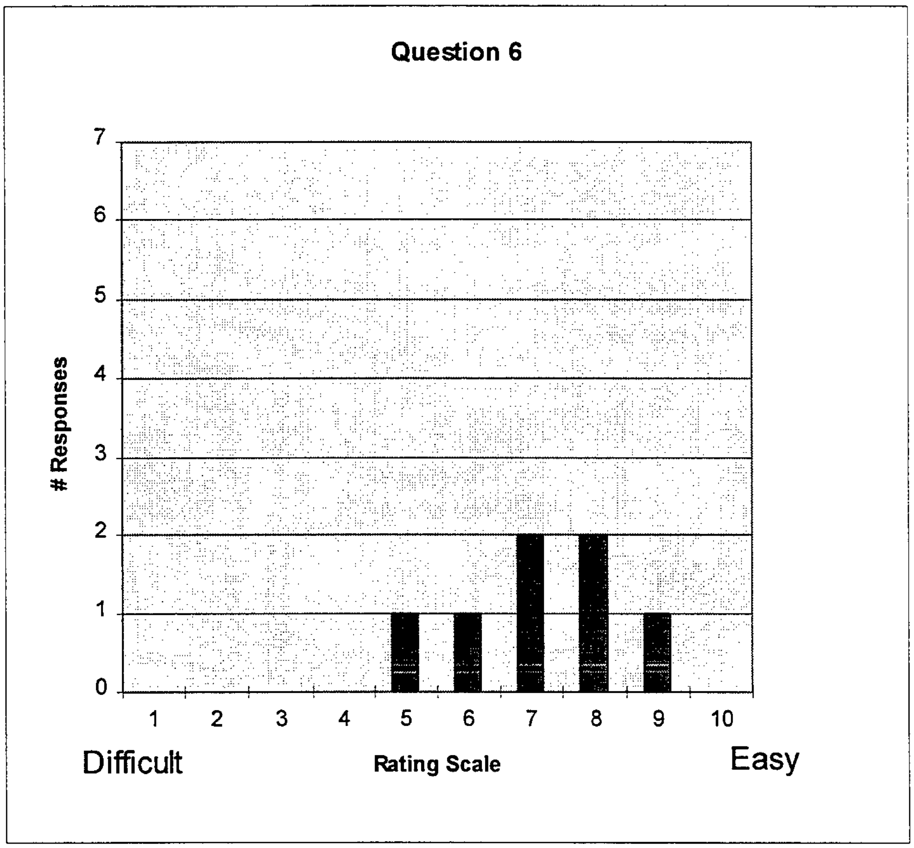


Question 5: The sequence of information on the screen was <Disorganized (1) to Organized (10)>

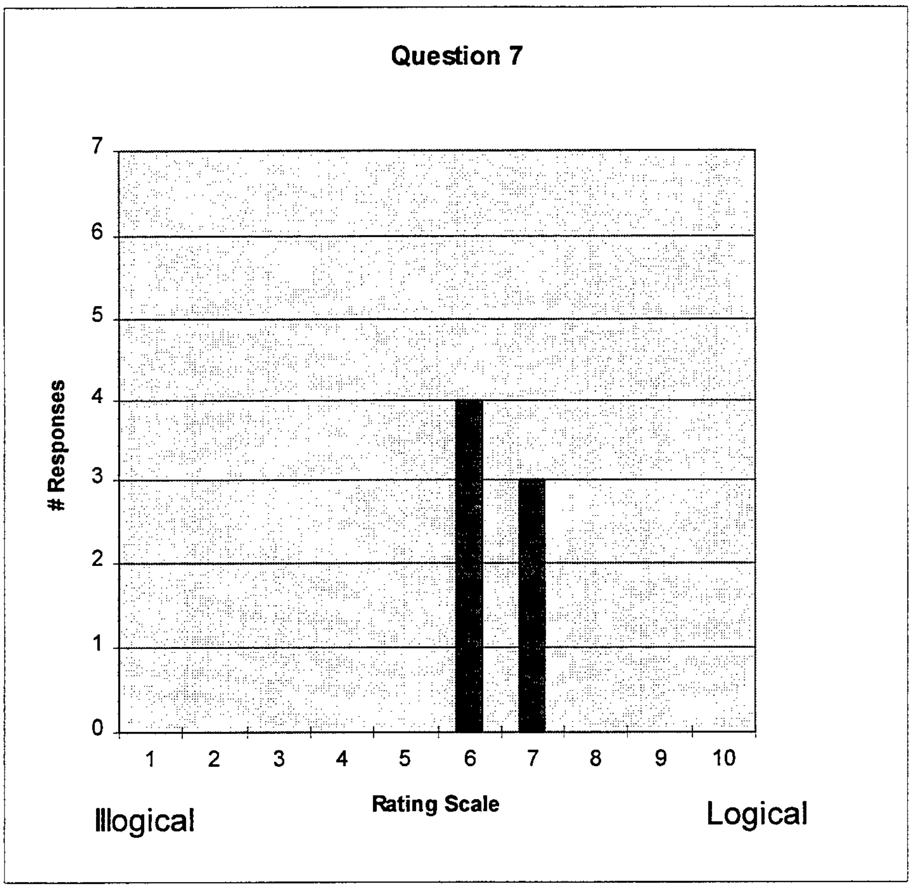


NAVIGATION

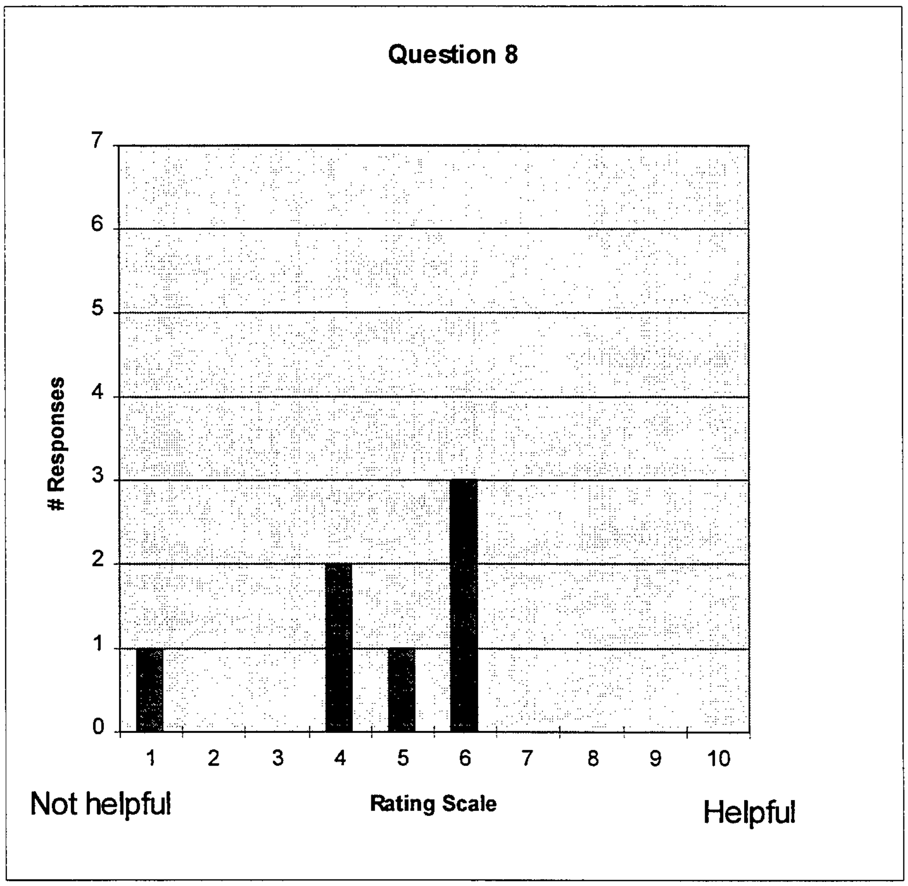
Question 6: Logging into the system and starting the task was<Difficult (1) to Easy (10)>



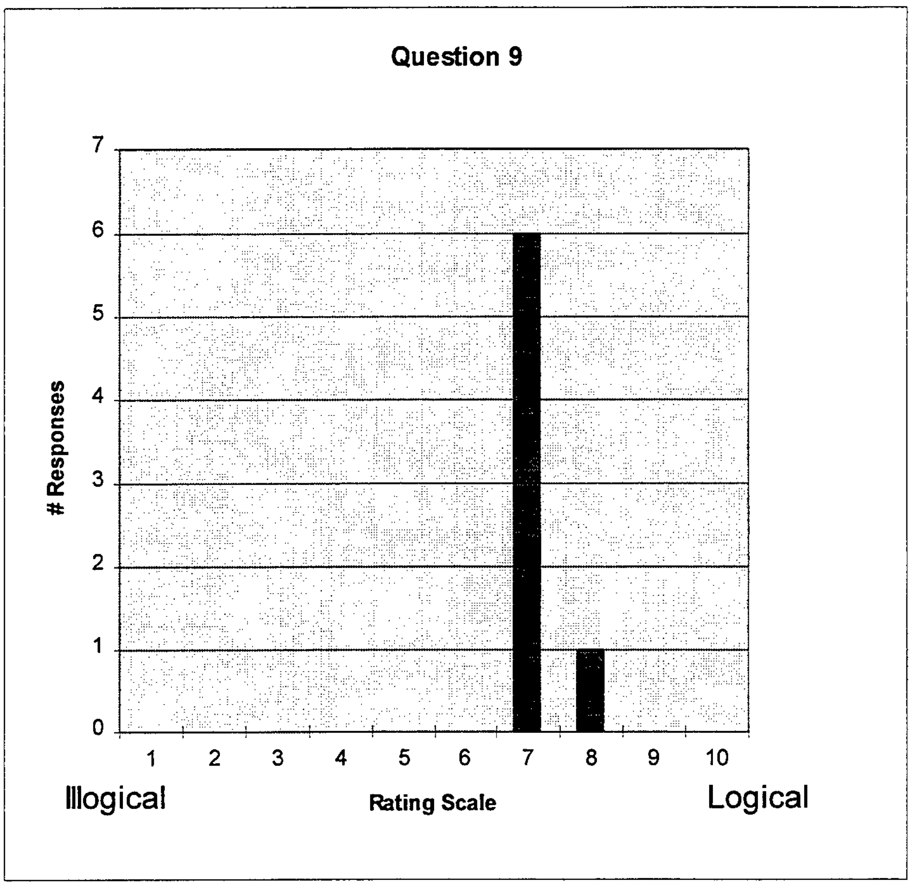
Question 7: Navigation among items (e.g. fill-ins) on the screen was <Illogical (1) to Logical (10)>



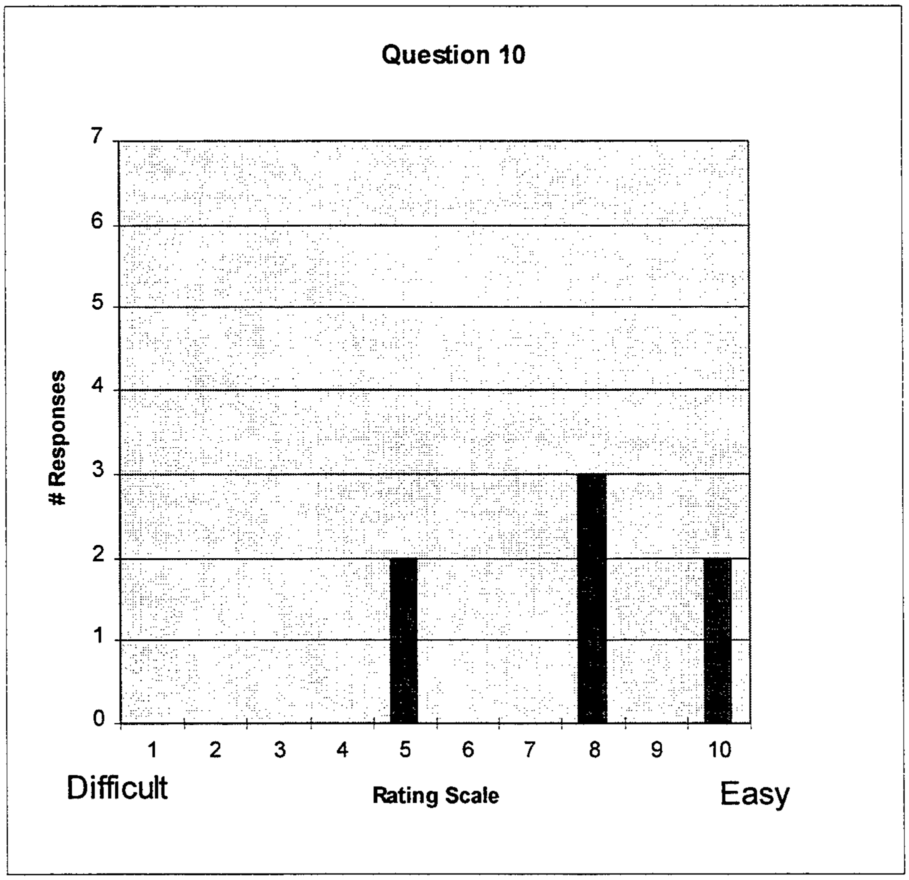
Question 8: Instructions on how to navigate from screen to screen was <Not helpful (1) to Helpful (10>



Question 9: The sequence of flow from one screen to the next was <Illogical (1) to Logical (10)>

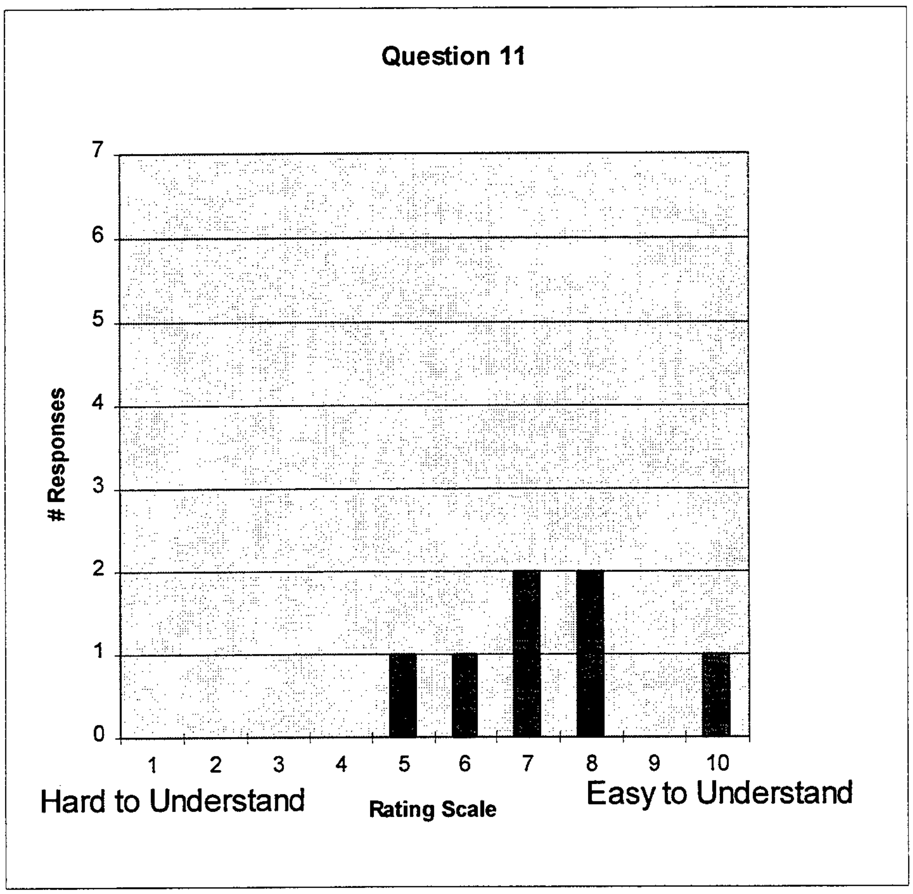


Question 10: Logging off the system was <Difficult (1) to Easy (10)>



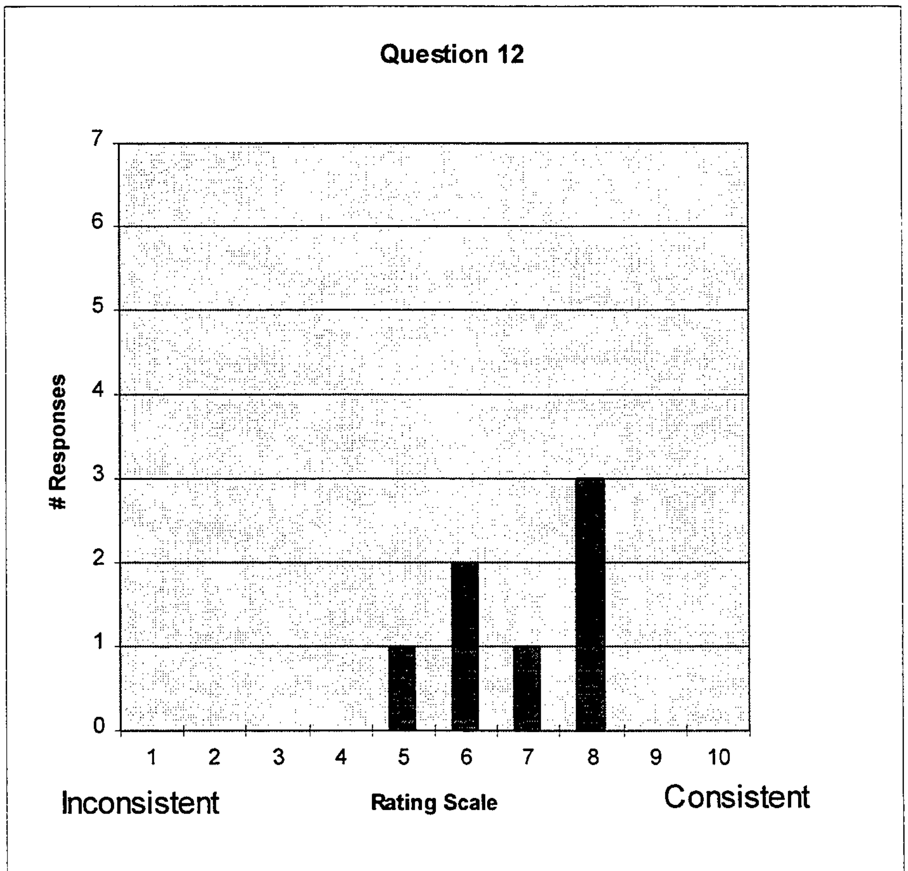
TERMINOLOGY

Question 11: The terminology used throughout the system was <Hard to understand (1) to Easy to understand (10)>

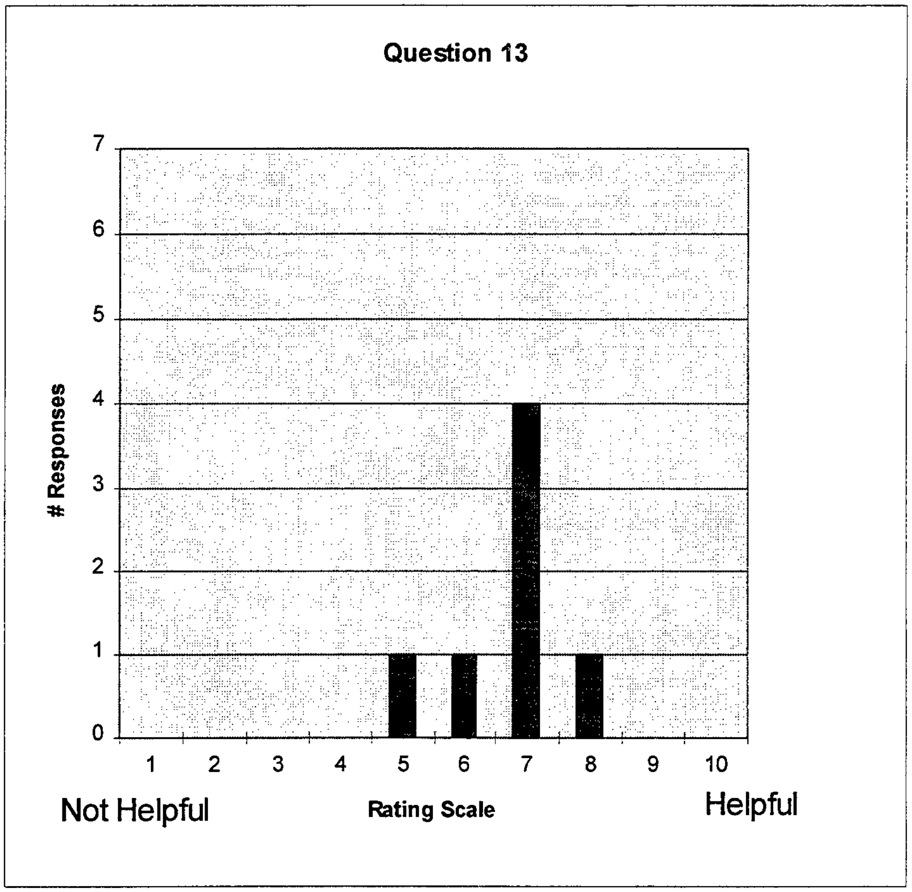


Question 12: In relation to the work you do, the use of terminology was

Inconsistent (1) to Consistent (10)>

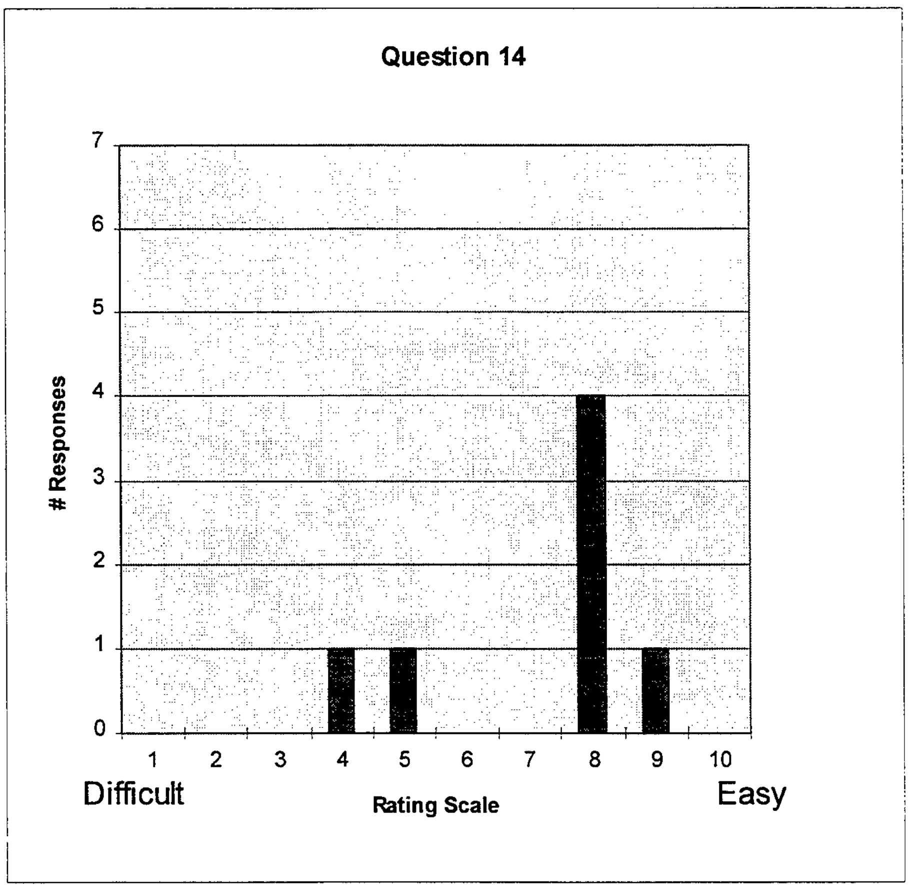


Question 13: The terminology used in messages was <Not helpful (1) to Helpful (10)>

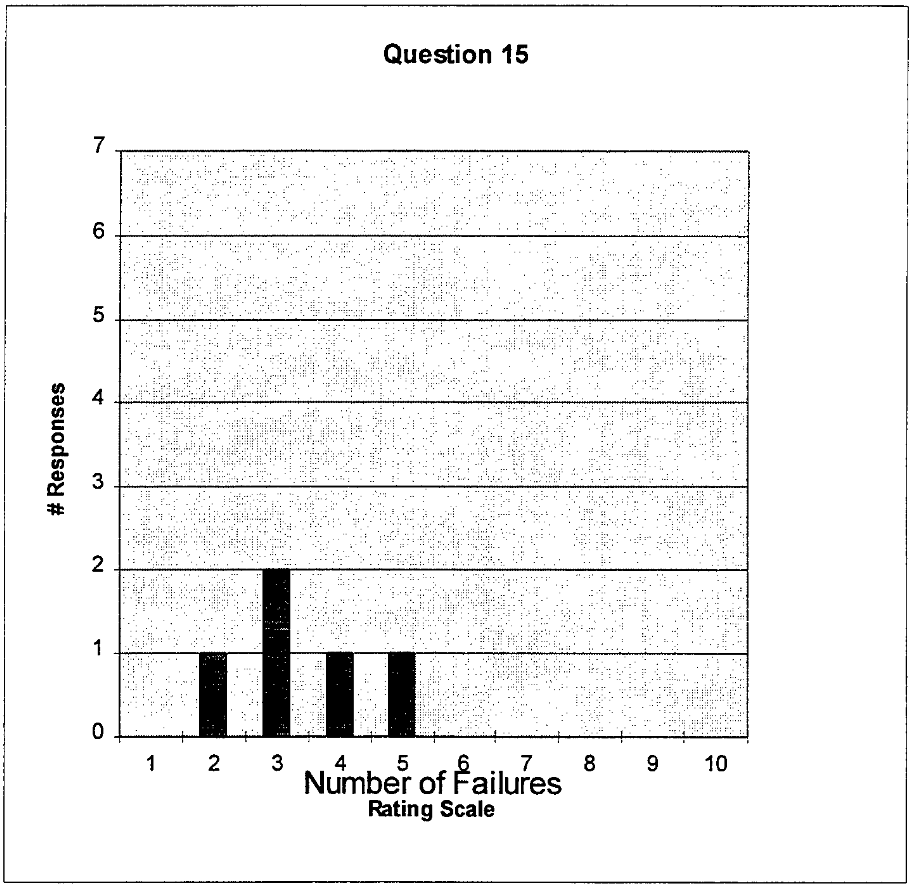


ERRORS

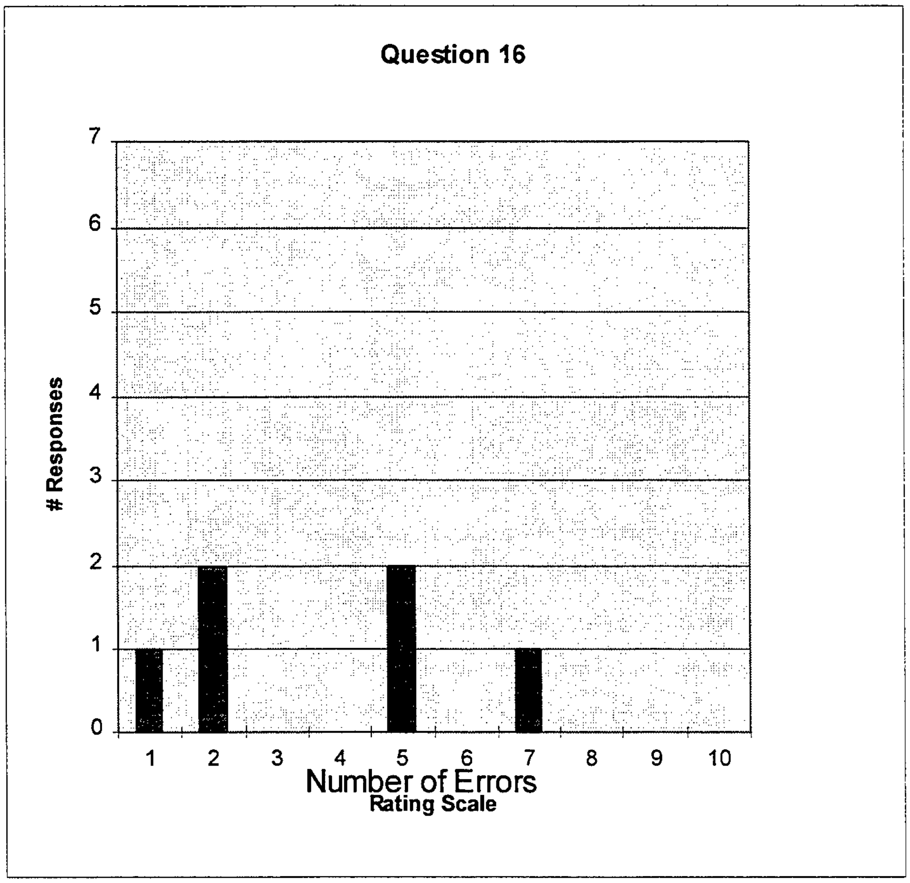
Question 14: Correcting mistakes was <Difficult (1) to Easy (10)>



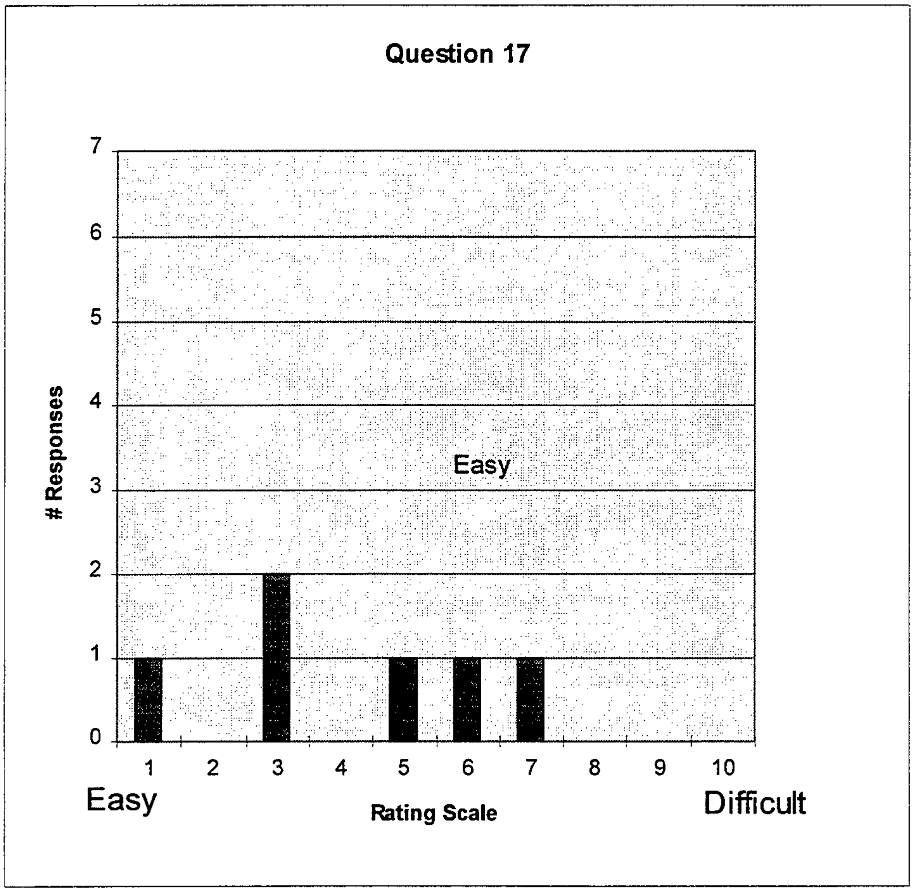
Question 15: The number of ITI-ALC system failures encountered was <# of failures>



Question 16: Number of error messages encountered was <# of errors>

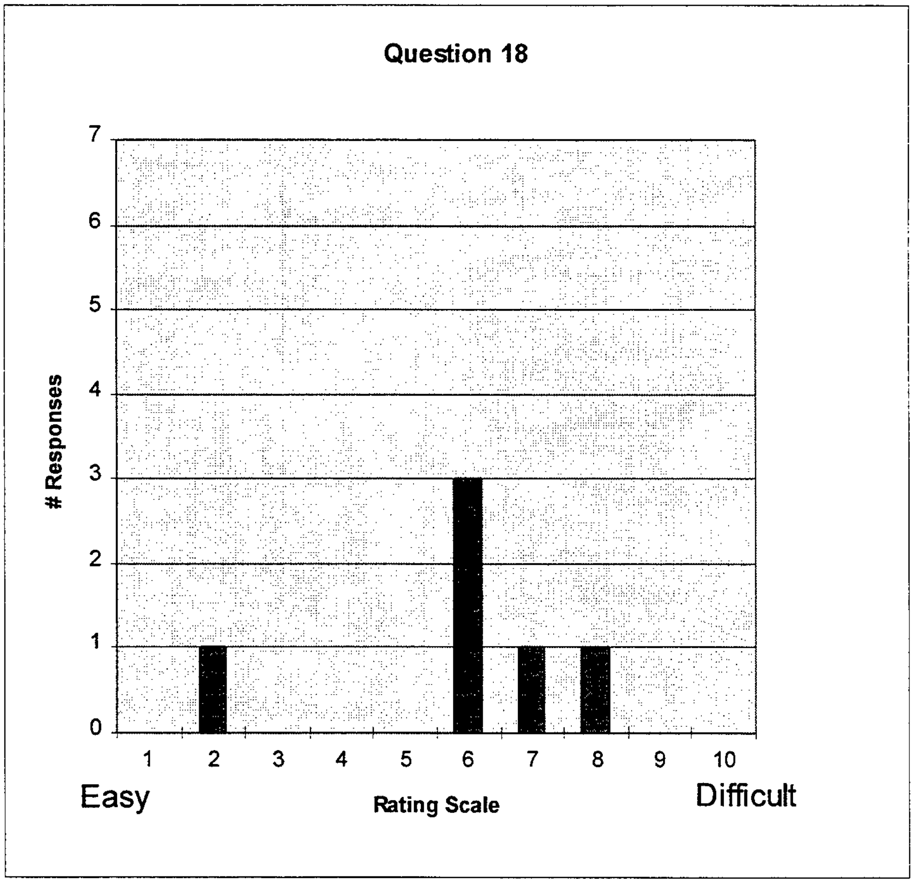


Question 17: Recovering from errors was <Easy (1) to Difficult (10)>

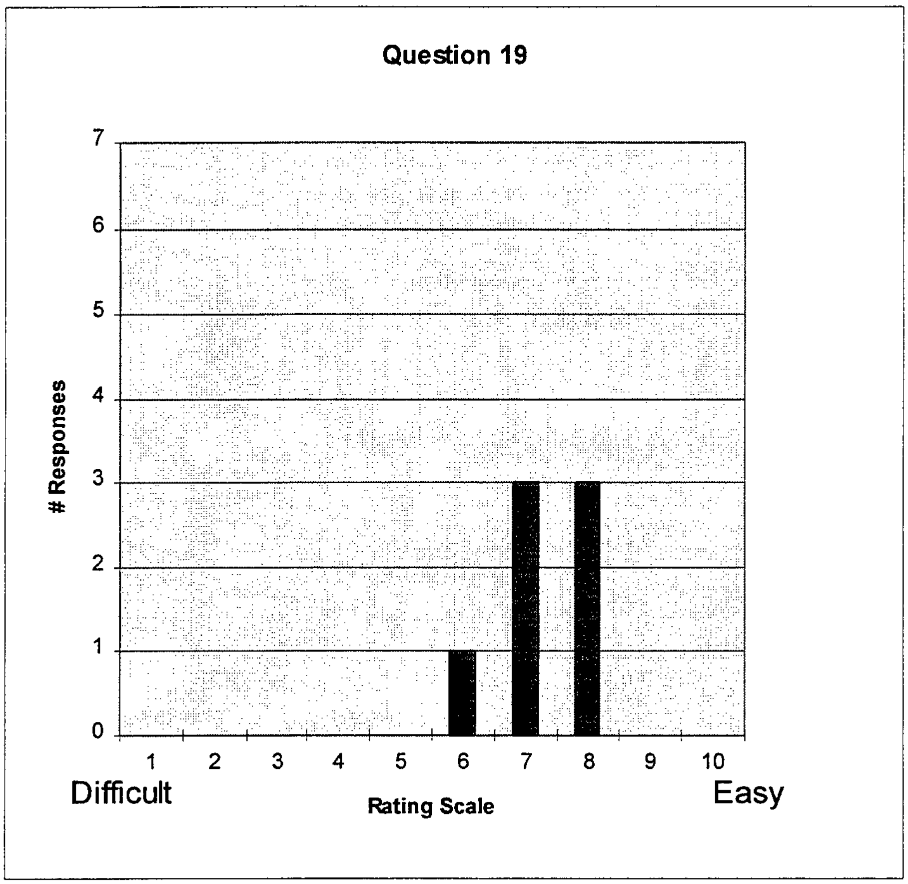


LEARNING

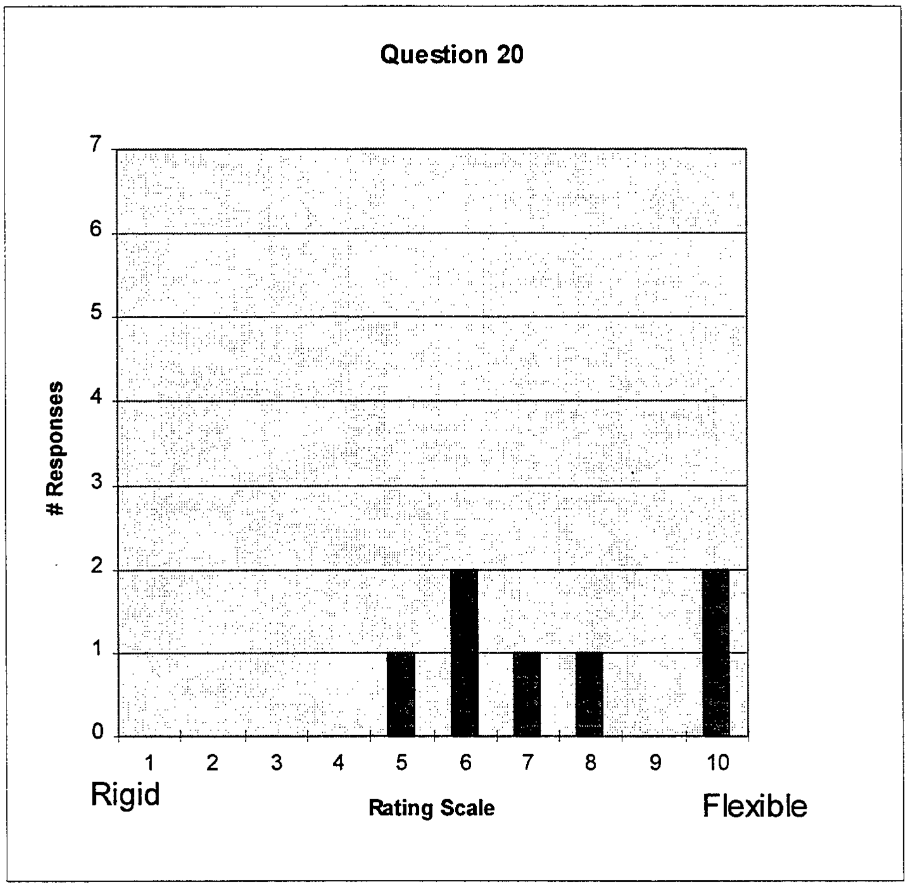
Question 18: Learning how to use the system was <Easy (1) to Difficult (10)>



Question 19: Remembering the names and use of commands was <Difficult (1) to Easy (10)>

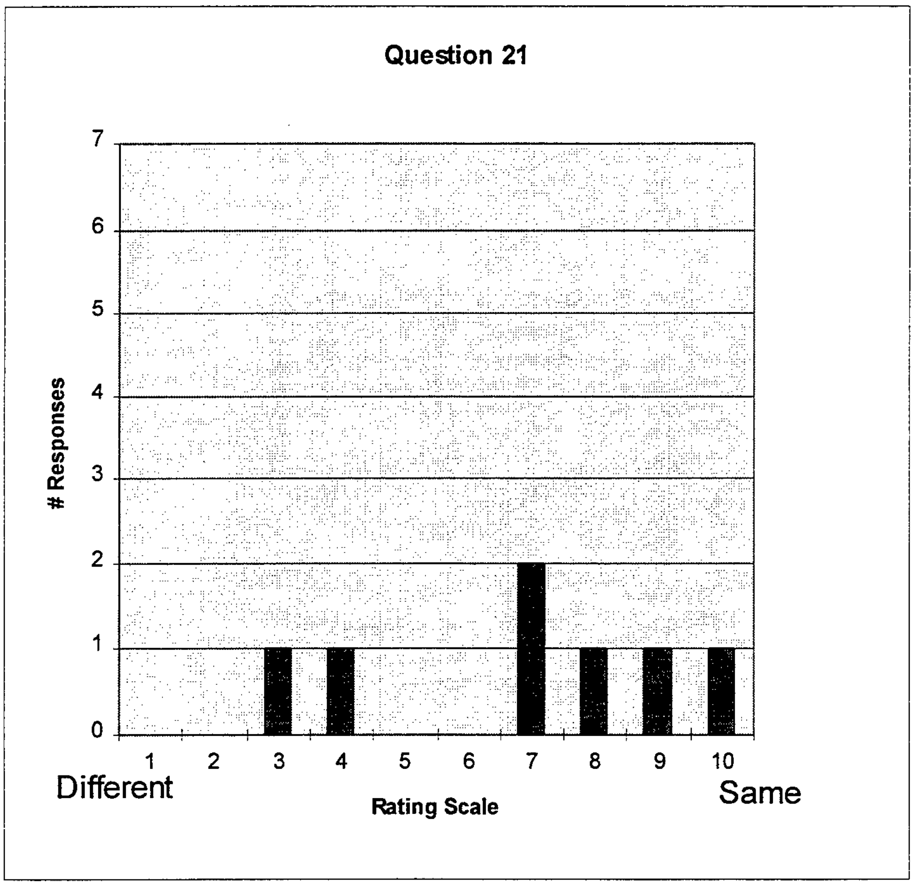


Question 20: Exploration of system functions was <Rigid (1) to Flexible (10)>



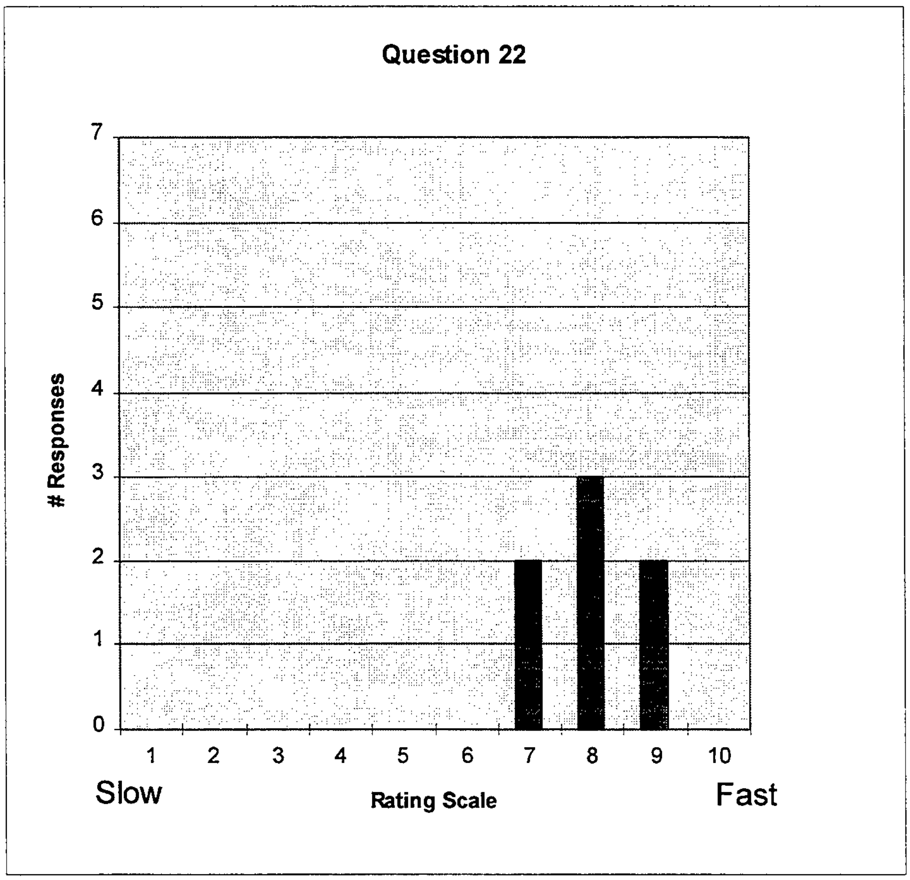
Question 21: The task flow between the real world and the system seemed to be the

<Different (1) to Same (10)>

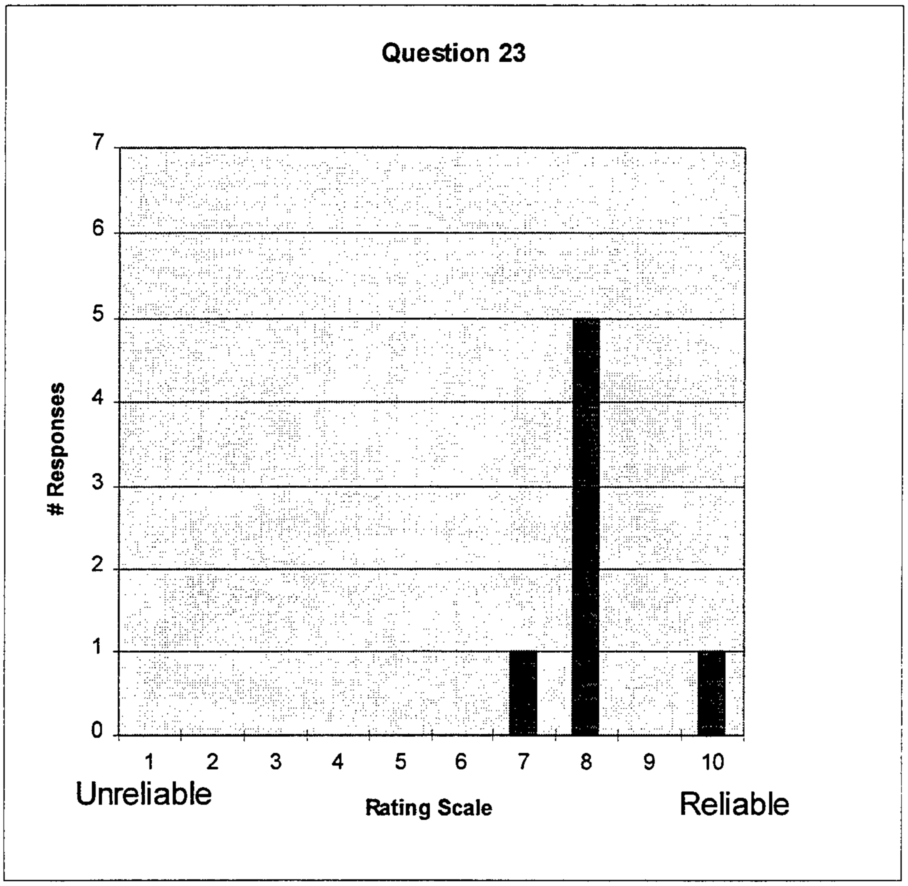


SYSTEM CAPABILITIES

Question 22: Response time from the system was <Slow (1) to Fast (10)>



Question 23: Overall, the system was <Unreliable (1) to Reliable(10)>



ITI-ALC

Question 24: What did you particularly like about ITI-ALC?

Total Number of Respondents (N): 7

Number of Responses to This Question (n): 7

---

1. my grand kids will love it

2. WORKING PROCESS

3. It gives basically all information which is needed to accomplish a work task.

4. something.to.help.mech

5. Overall sequence was great. Flowing from one step to another, fairly easy with minor problems.

   Research group personnel very helpful and friendly.

   Found several areas where modifications needed to be, and changes seemed very easy.

6. Flow of work process. Easier to track work and parts

7. STEP BY PROCEDURE

Question 25: What in particular did you NOT like about ITI-ALC?

Total Number of Respondents (N):	7
Number of Responses to This Question (n):	6

1. I will be dead before I get to use it

2. No instructions up front to navigate

3. nothing

4. Some commands were a little misleading. Some steps hard to follow. Not enough information on views of work areas

5. overall system needs to be more user friendly. More T.O. information needs to be installed

6. NOTHING

Question 26: What recommendations would you make for improving ITI-ALC?

Total Number of Respondents (N): 7

Number of Responses to This Question (n): 7

---

1. try to make it more user friendly

2. NEED MORE SCHOOLING ON COMPUTER SYSTEMS

3. Make it more user friendly.

4. HAVE A FEW MORE STUDIES

5. Provide user friendly computer classes to ensure continuity between operators.

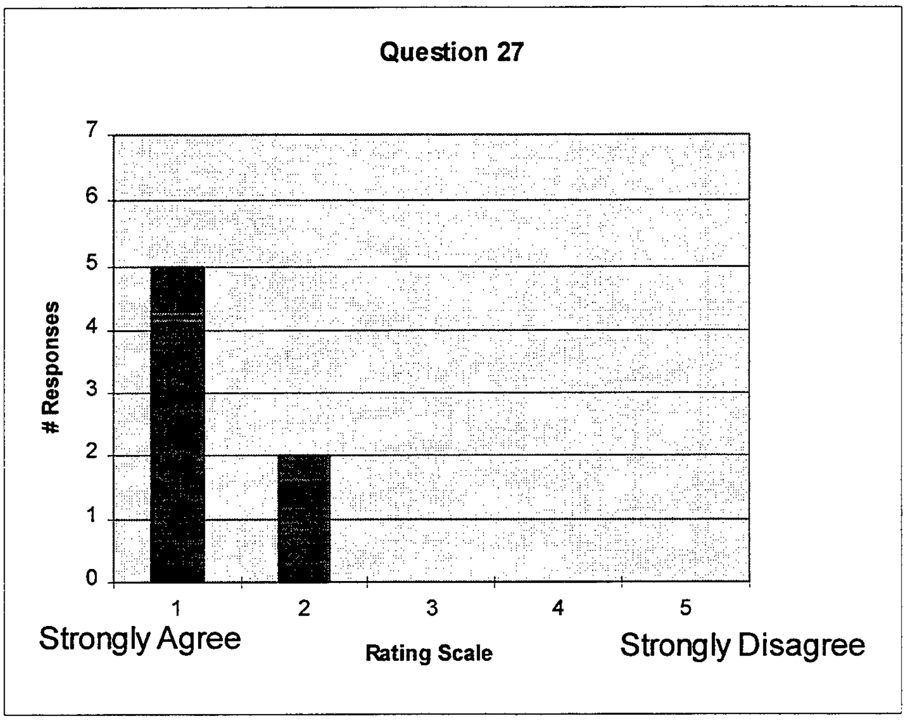
6. More input from mechanics.

7. HAVE A PRESENTATION ON BASIC COMPUTER

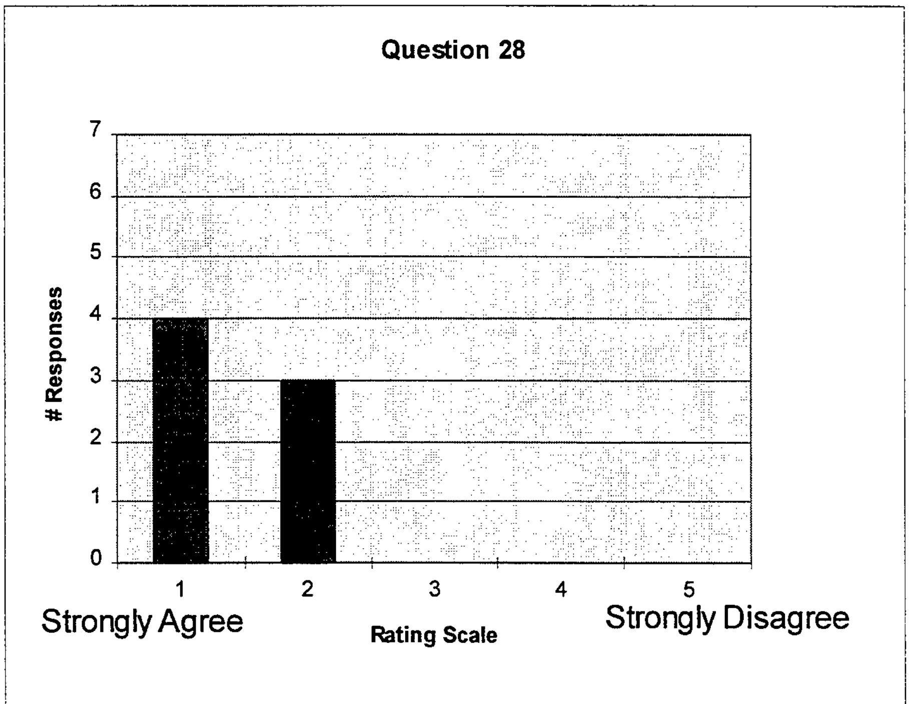
SKILLS

GSS

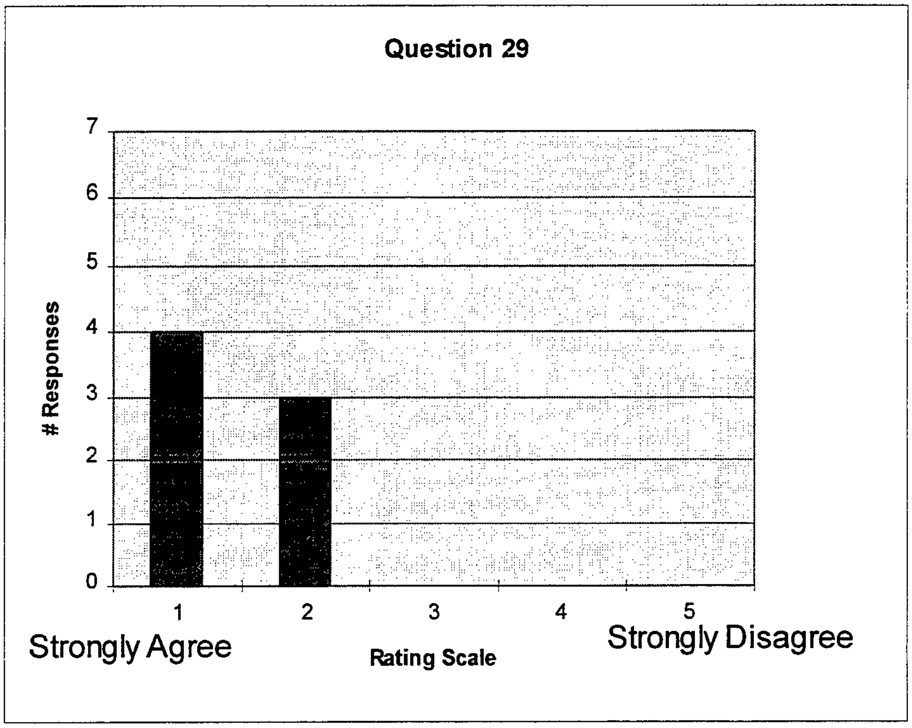
Question 27: I would use a Group Support System to evaluate another prototype.



Question 28: The GSS helped me to evaluate the rapid prototype faster than if I didn't use it.



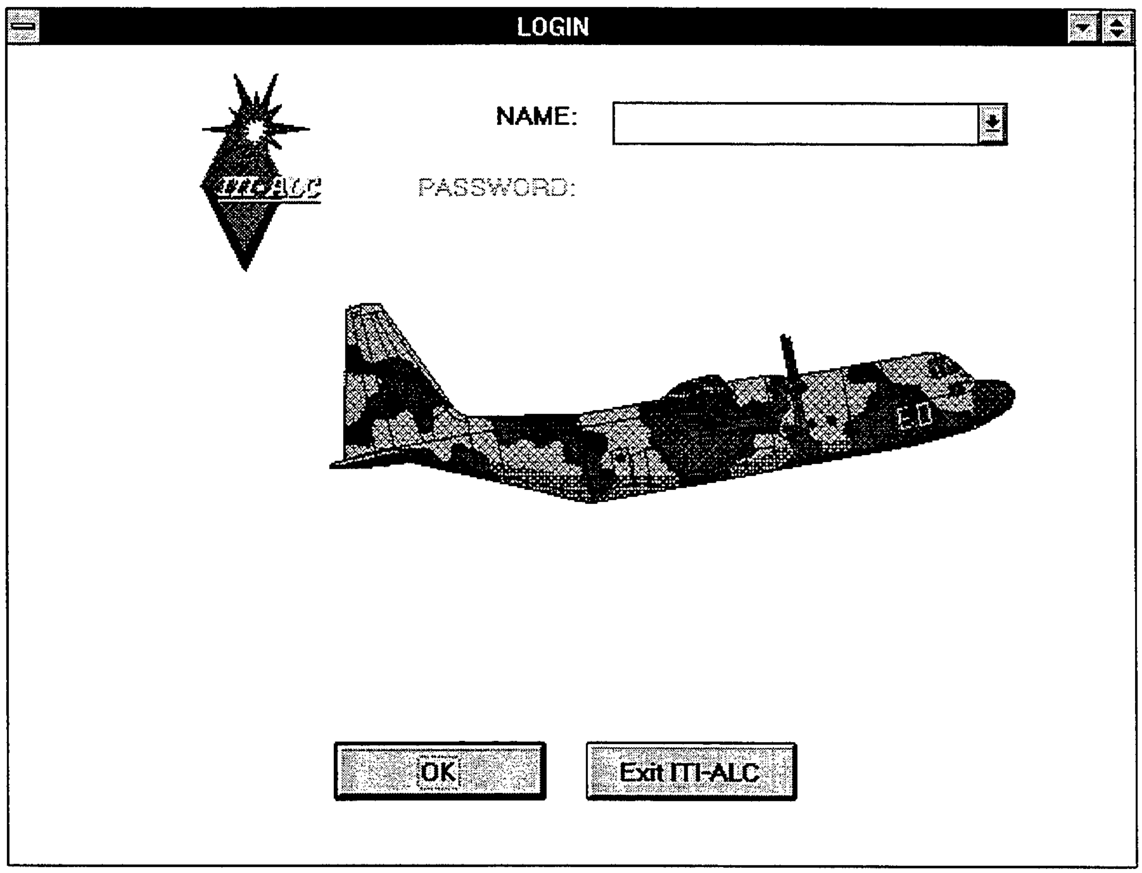
Question 29: The GSS was effective in helping me evaluate the rapid prototype.



Appendix H:

Scenario Screen Sequence and Observation Notes

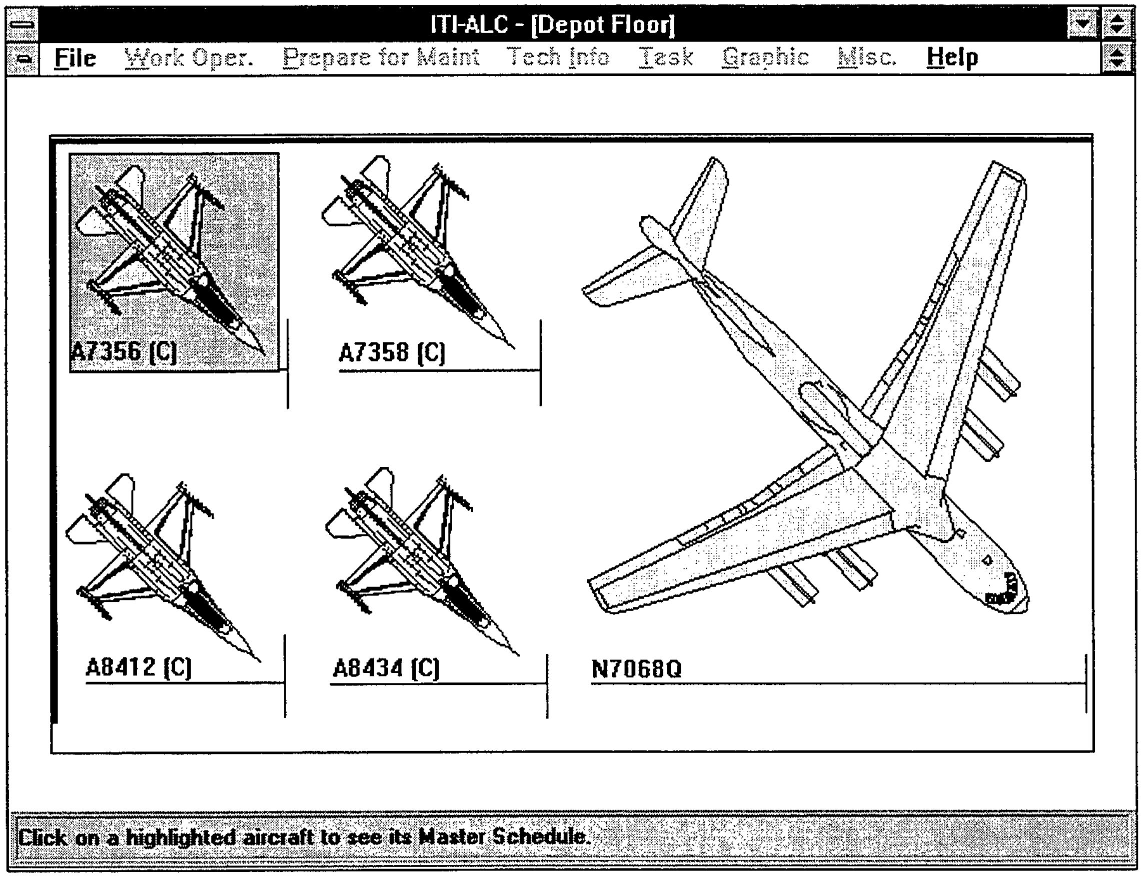
Appendix H presents the screens seen by the users during the evaluation of the rapid prototype. The screen is at the top of each page, with related comments by the observers beneath it. The listing is an aggregation of all observer notes for that screen.



•Didn't pick a name

•No selection of role before ok

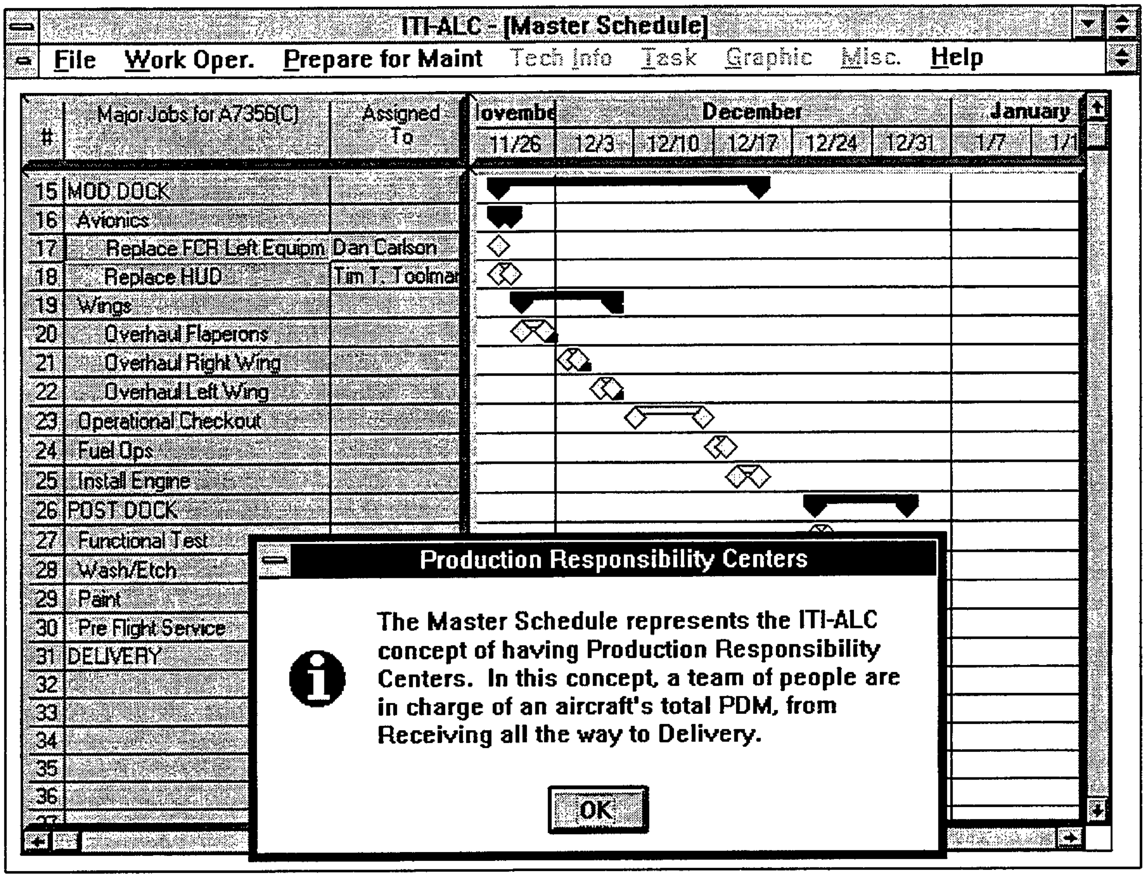
•Question about whether to input name. Provided menu not clear
Wasted step--go ahead list people out



•Double click hides schedule--A general problem with minimize and maximize without executing commands (S/W problem)

•Individual was a novice user, unfamiliar with general computer procedures

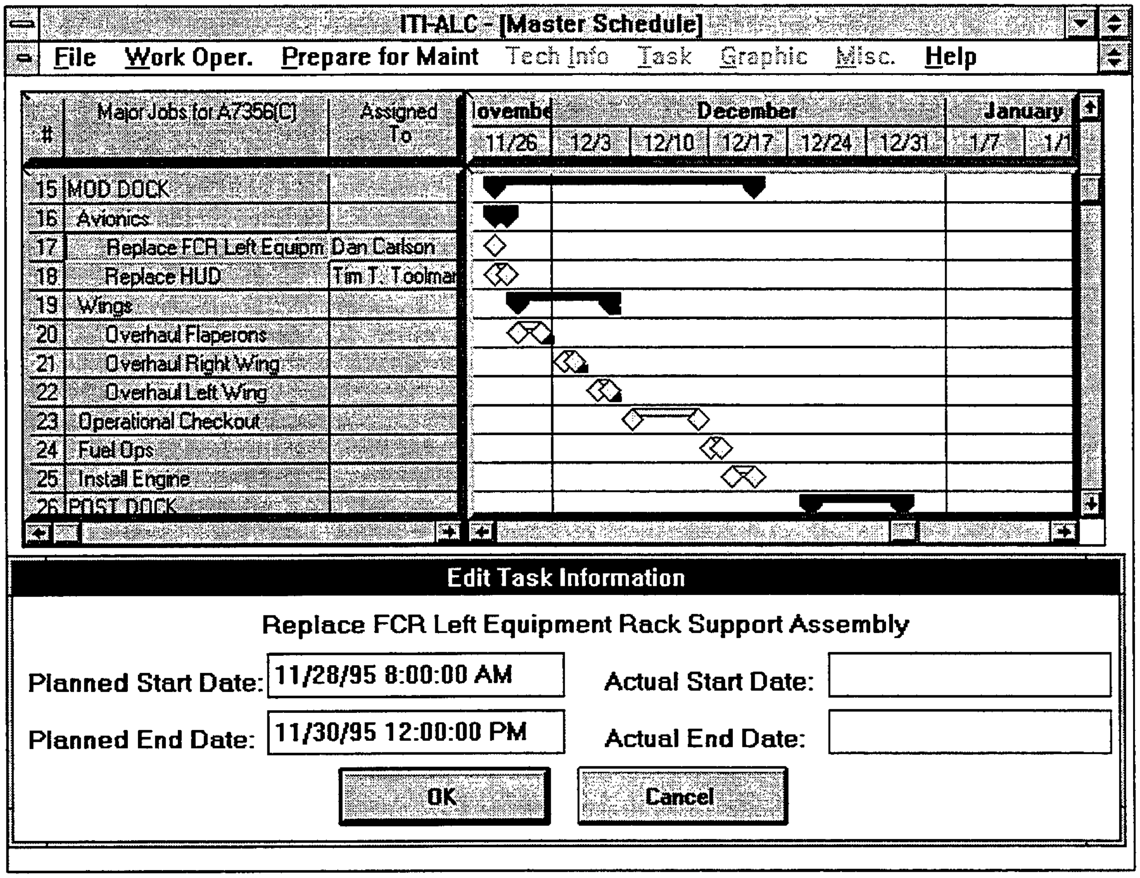
•Was able to learn some of the interface thru trial and error (e.g. logout)



•User selected HUD

•User canceled window

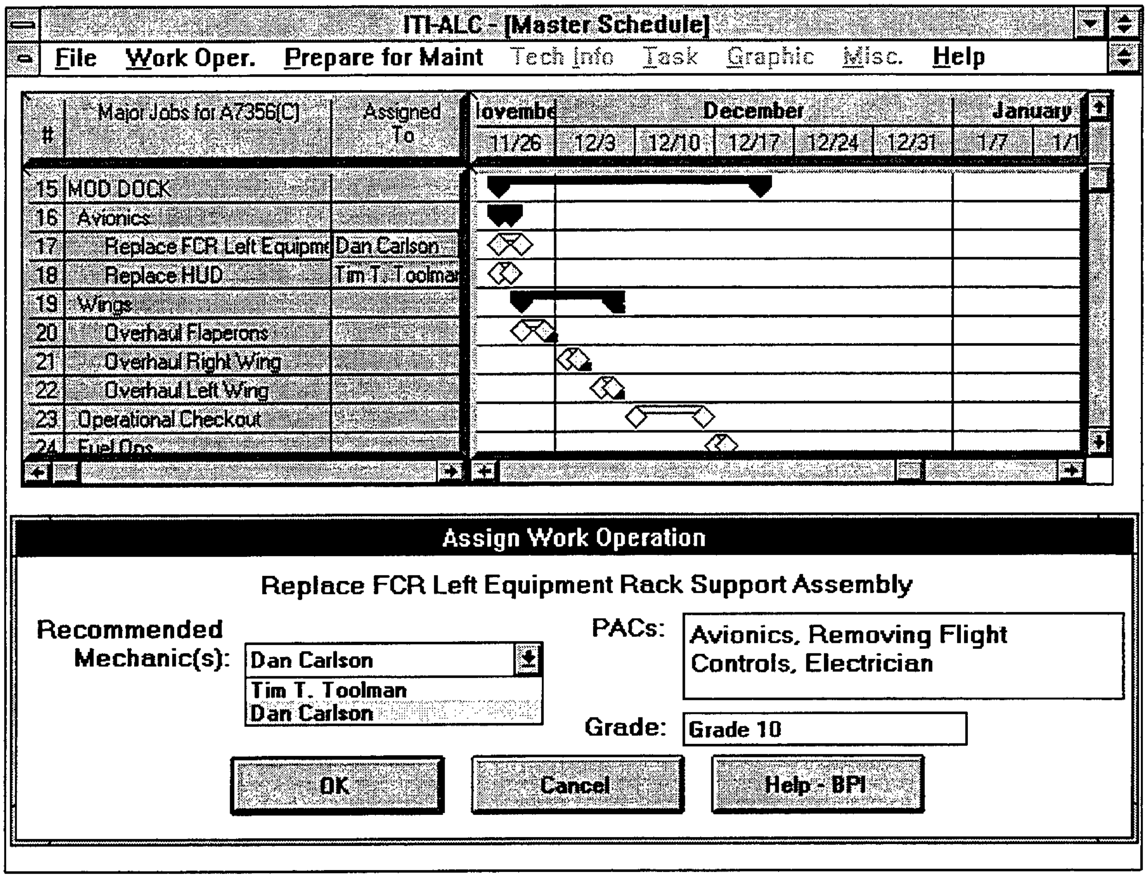
•Would be nice to have major jobs on one graph along with pertinent information



•Tim T. Toolman ended up blank

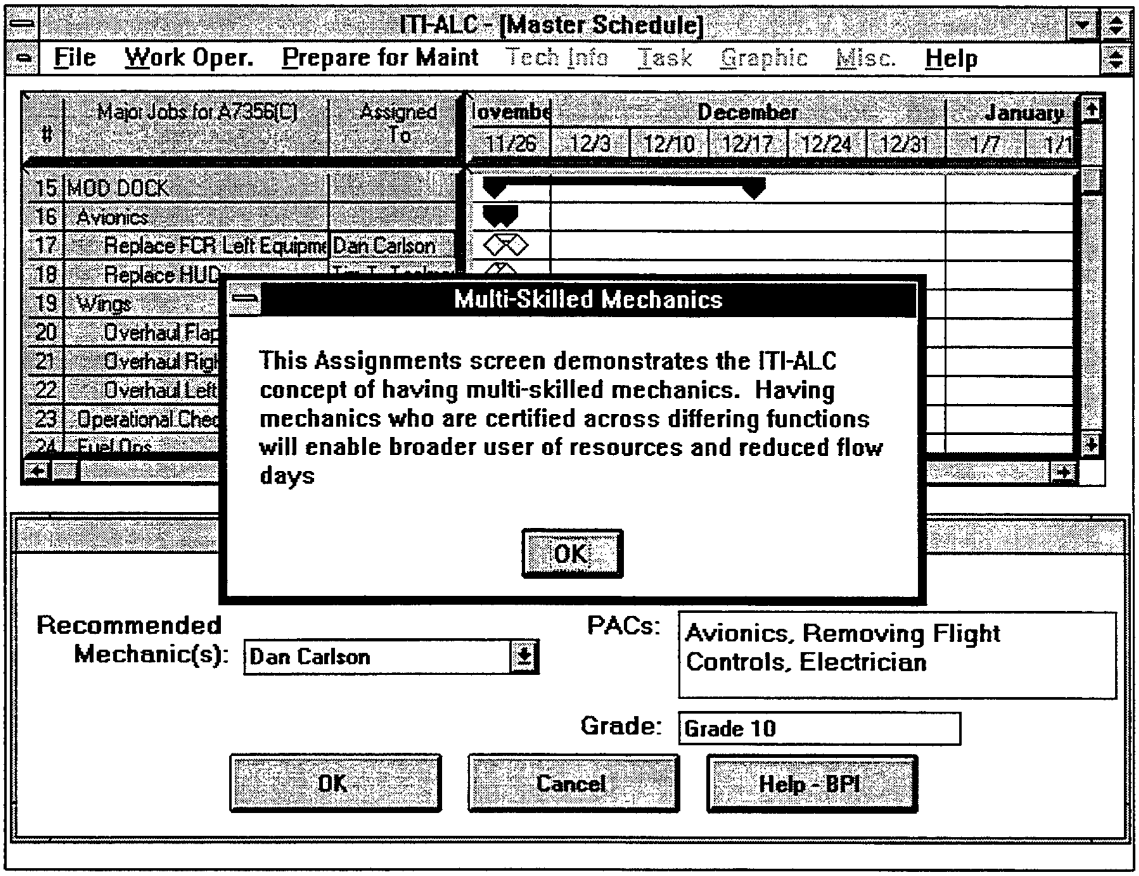
•*Searching*--clicks on numbers 17, then 18, then clicked on Dan Carlson, then Tim T. Toolman

•User tried editing schedule without closing dialog box

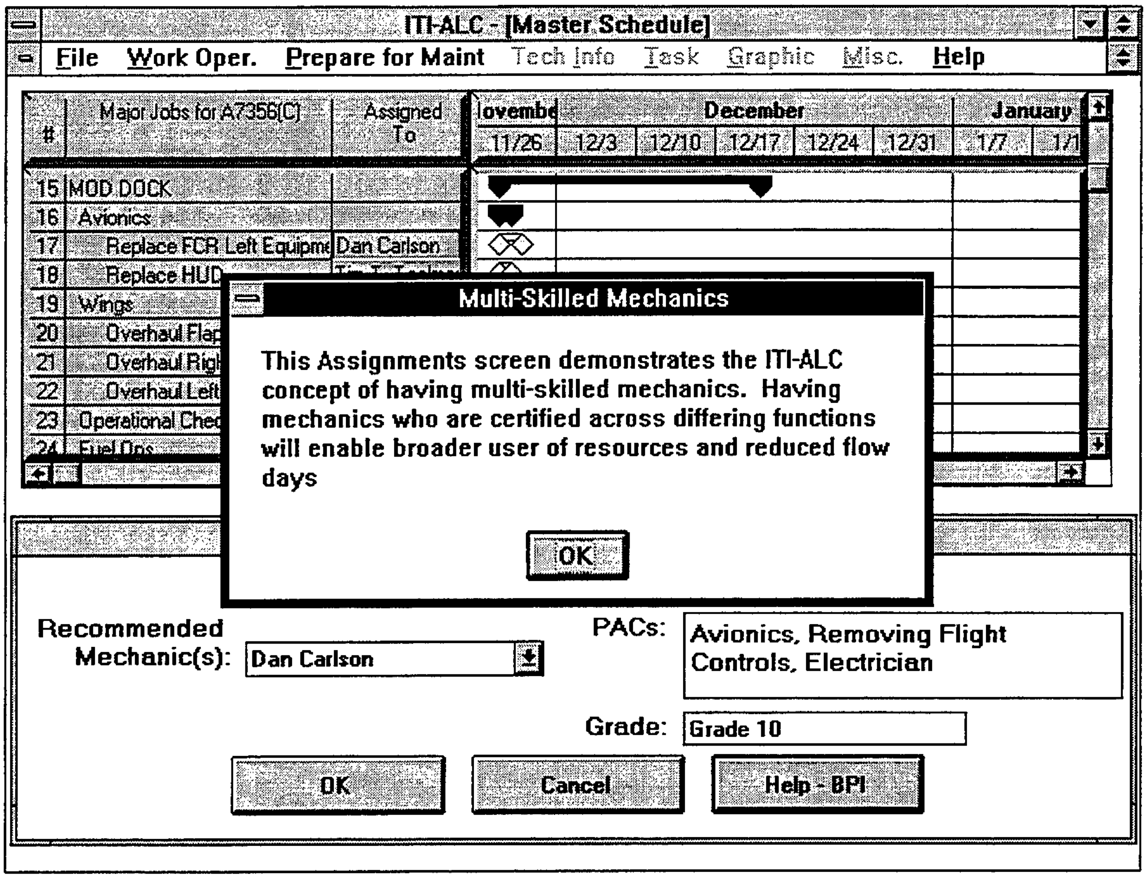


•Difficulty with mechanic list box

•Hidden functions under name or task isn't clear--ended up closing application trying to find menu item in upper menu box



ITI-ALC - [Master Schedule]
File Work Oper. Prepare for Maint Tech Info Task Graphic Misc. Help
Major Jobs for A7356(C) Assigned To
ovembe December January
11/26 12/3 12/10 12/17 12/24 12/31 1/7 1/1
15 MOD DOCK
16 Avionics
17 Replace FCR Left Equipme Dan Carlson
18 Replace HUD
19 Wings
20 Overhaul Flap
21 Overhaul Righ
22 Overhaul Left
23 Operational Chec
24 Fuel Ops
Multi-Skilled Mechanics
This Assignments screen demonstrates the ITI-ALC concept of having multi-skilled mechanics. Having mechanics who are certified across differing functions will enable broader user of resources and reduced flow days
OK
Recommended Mechanic(s): Dan Carlson
PACs: Avionics, Removing Flight Controls, Electrician
Grade: Grade 10
OK
Cancel
Help - BPI


ITI-ALC - [Master Schedule]
File Work Oper. Prepare for Maint Tech Info Task Graphic Misc. Help
Major Jobs for A7356(C) Assigned To
lovembe December January
11/26 12/3 12/10 12/17 12/24 12/31 1/7 1/1
15 MOD DOCK
16 Avionics
17 Replace FCR Left Equipme Dan Carlson
18 Replace HUD
19 Wings
20 Overhaul Flap
21 Overhaul Rig
22 Overhaul Left
23 Operational Chec
24 Fuel Ops
Multi-Skilled Mechanics
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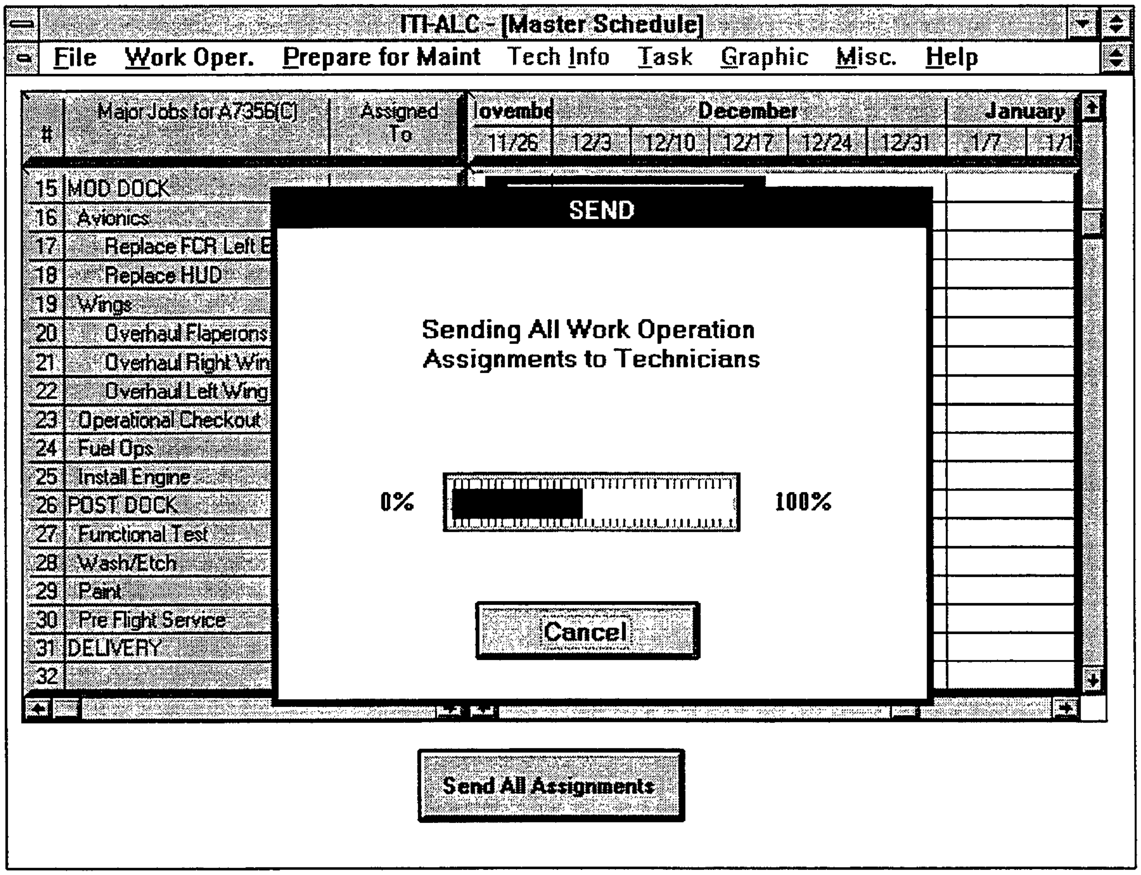
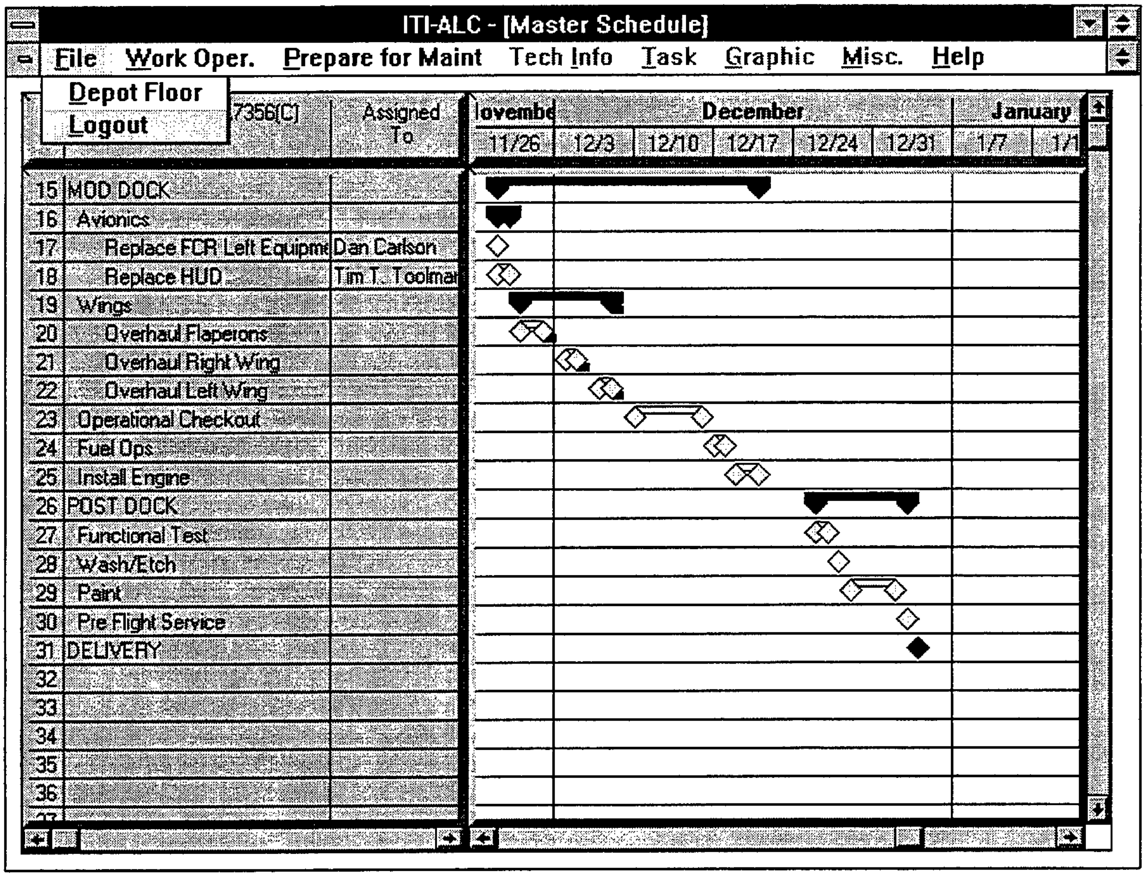
OK
Recommended Mechanic(s): Dan Carlson
PACs: Avionics, Removing Flight Controls, Electrician
Grade: Grade 10
OK
Cancel
Help - BPI



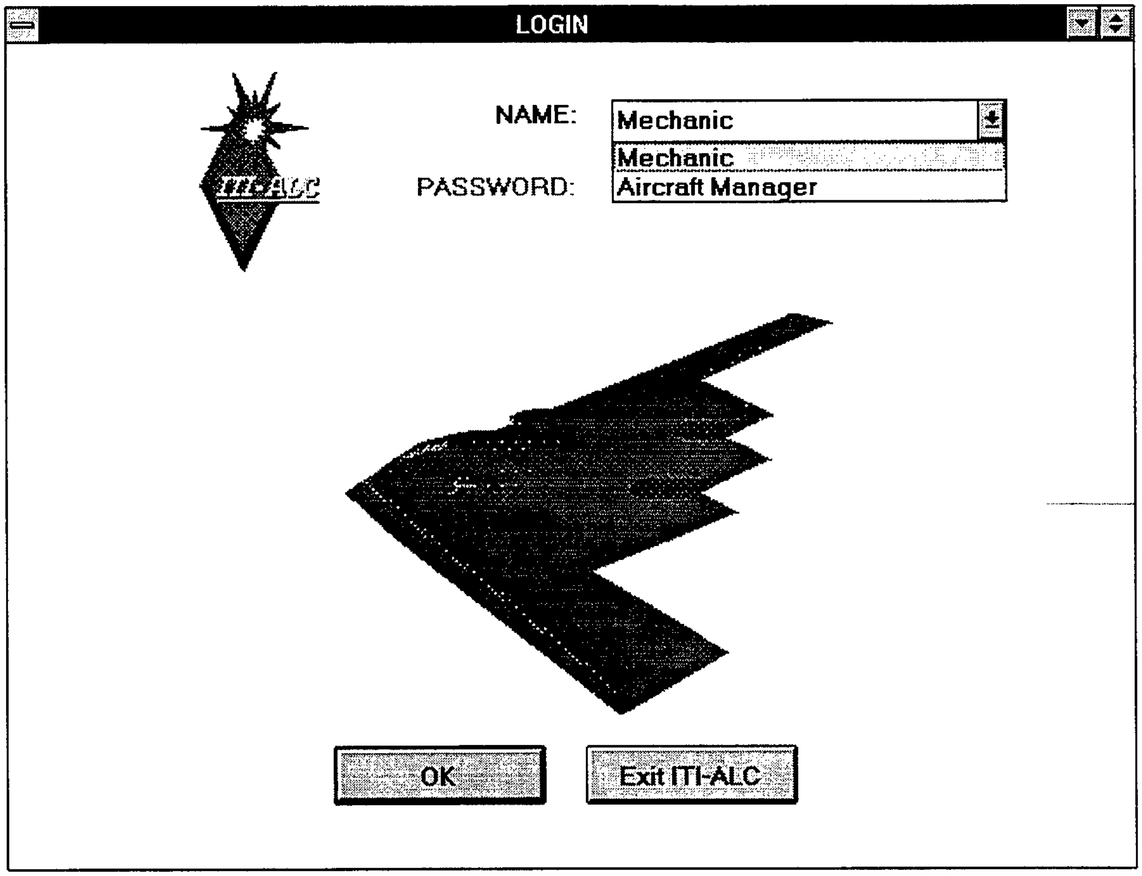
ITI-ALC - [Master Schedule]
File Work Oper. Prepare for Maint Tech Info Task Graphic Misc. Help
Major Jobs for A7356(C)
Assigned To
December
January
11/26 12/3 12/10 12/17 12/24 12/31 1/7
15 MOD DOCK
16 Avionics
17 Replace FCR Left E
18 Replace HUD
19 Wings
20 Overhaul Flaperons
21 Overhaul Right Win
22 Overhaul Left Wing
23 Operational Checkout
24 Fuel Ops
25 Install Engine
26 POST DOCK
27 Functional Test
28 Wash/Etch
29 Paint
30 Pre Flight Service
31 DELIVERY
32
SEND
Sending All Work Operation Assignments to Technicians
0%
100%
Cancel
Send All Assignments

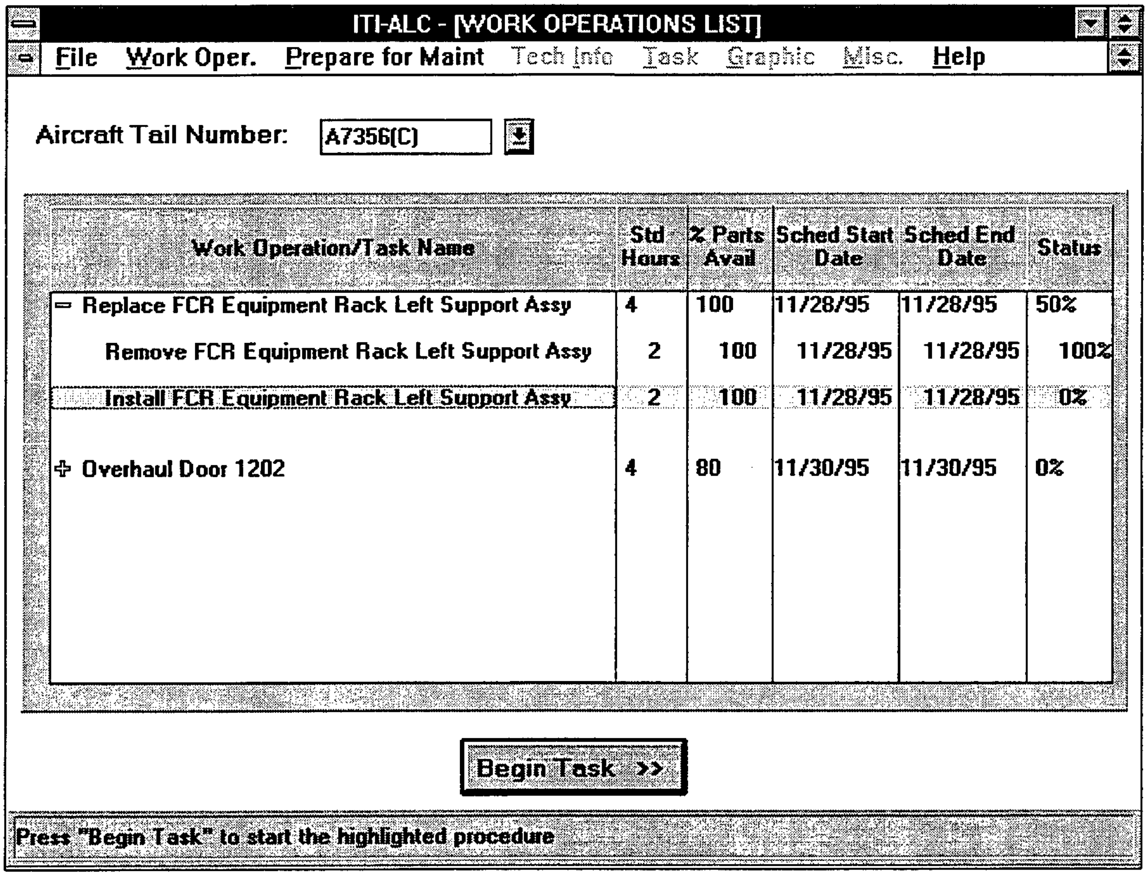


•User kept looking for the words "Sign off"

•Looked at Logout about 3 times and finally selected it

•User was uneasy about using menu selection


LOGIN
NAME:
Mechanic
Mechanic
Aircraft Manager
PASSWORD:
ITI-ALC
OK
Exit ITI-ALC



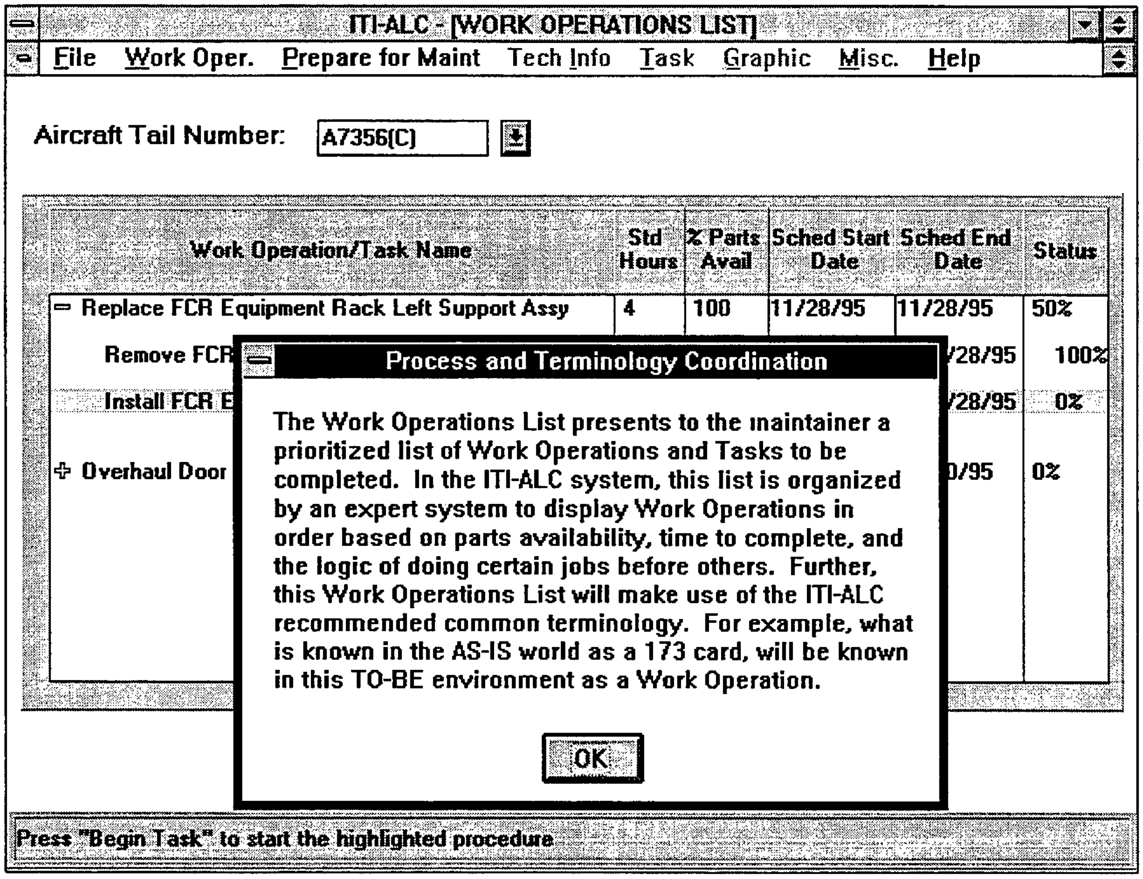
•Asked what status meant

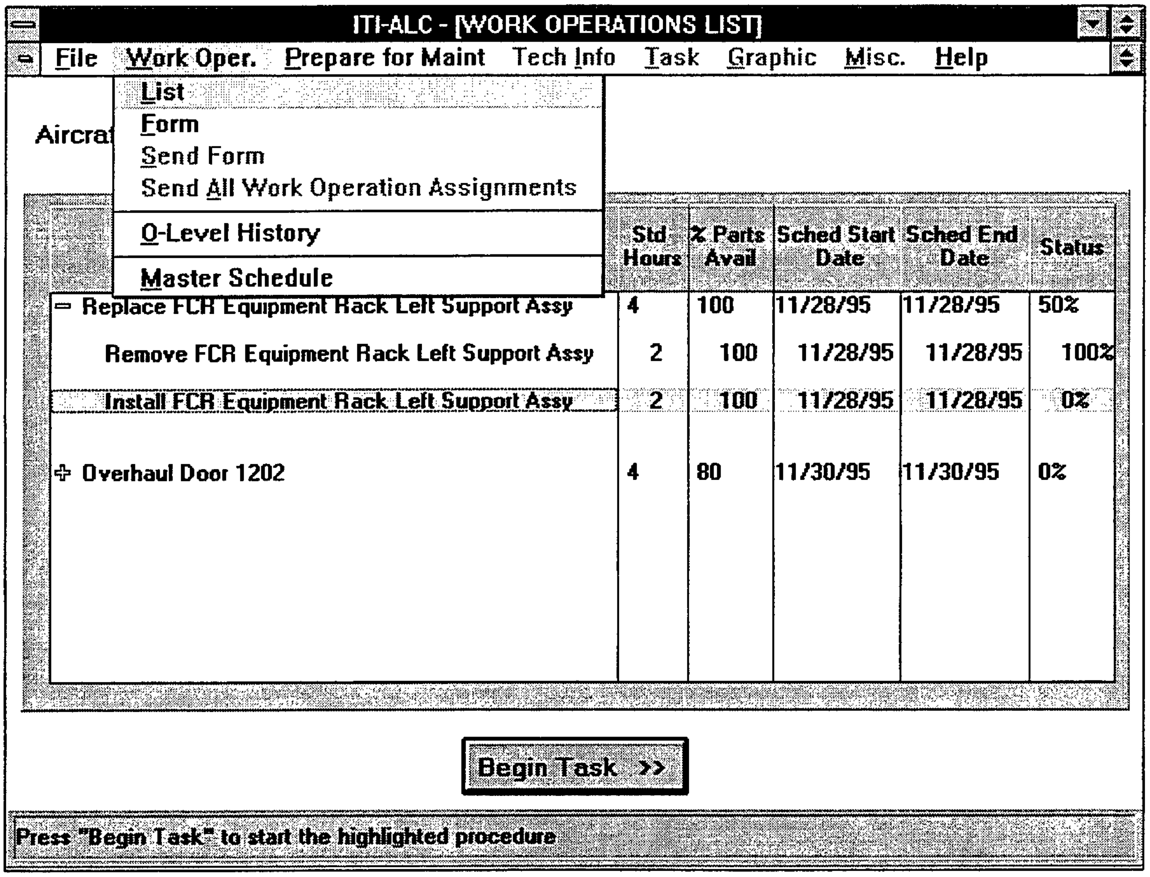
-thought but not sure it was completion

•Review write ups

-began task before receiving tech data

-began task before reviewing Support. equipment


ITI-ALC - [WORK OPERATIONS LIST]
File Work Oper. Prepare for Maint Tech Info Task Graphic Misc. Help
Aircraft Tail Number: A7356(C)
Work Operation/Task Name
Std Hours
% Parts Avail
Sched Start Date
Sched End Date
Status
Replace FCR Equipment Rack Left Support Assy 4 100 11/28/95 11/28/95 50%
Remove FCR
/28/95 100%
Install FCR E
/28/95 0%
Overhaul Door
0/95 0%
Process and Terminology Coordination
The Work Operations List presents to the maintainer a prioritized list of Work Operations and Tasks to be completed. In the ITI-ALC system, this list is organized by an expert system to display Work Operations in order based on parts availability, time to complete, and the logic of doing certain jobs before others. Further, this Work Operations List will make use of the ITI-ALC recommended common terminology. For example, what is known in the AS-IS world as a 173 card, will be known in this TO-BE environment as a Work Operation.
OK
Press "Begin Task" to start the highlighted procedure



- Wasn't sure what "O" meant in O-level on the menu
  - suggested to not abbreviate

- O-level History not obvious to review previous write-ups

ITI-ALC - [ORGANIZATIONAL LEVEL HISTORY]

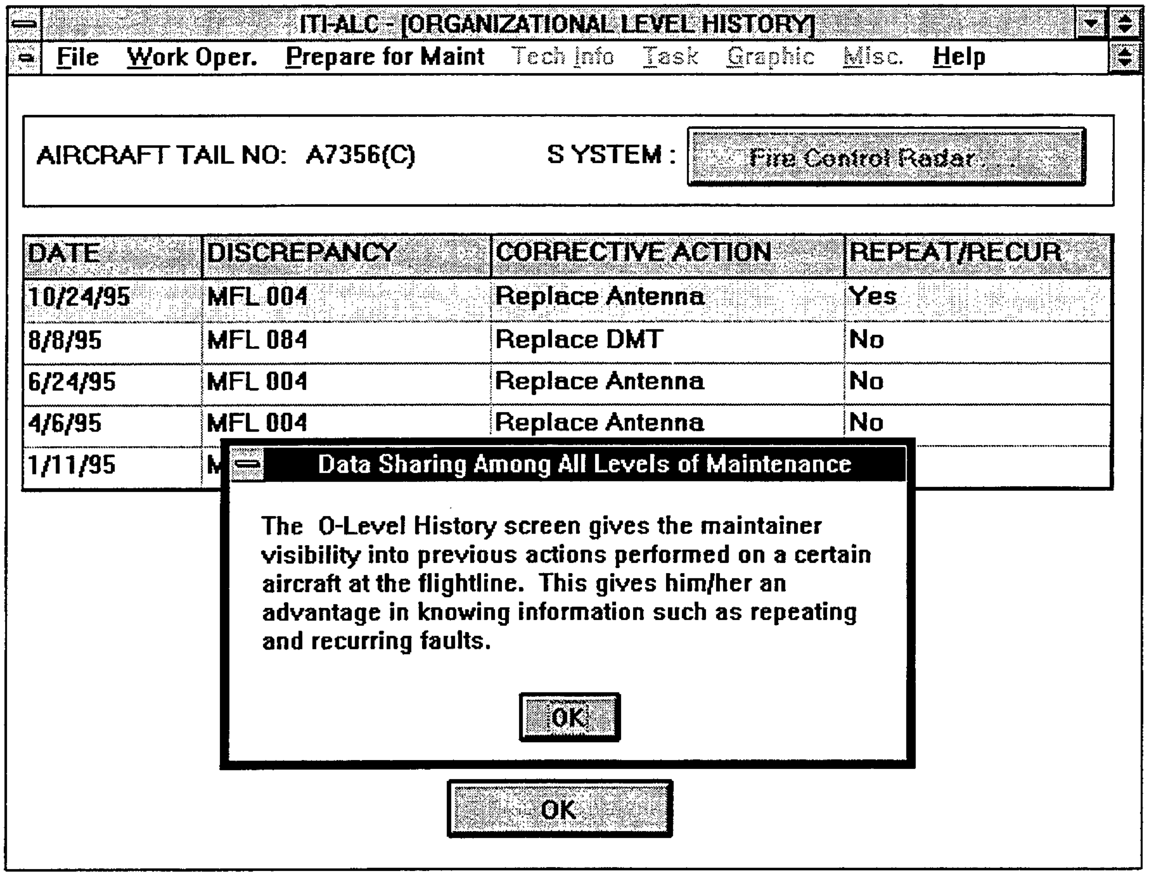
File Work Oper. Prepare for Maint Tech Info Task Graphic Misc. Help

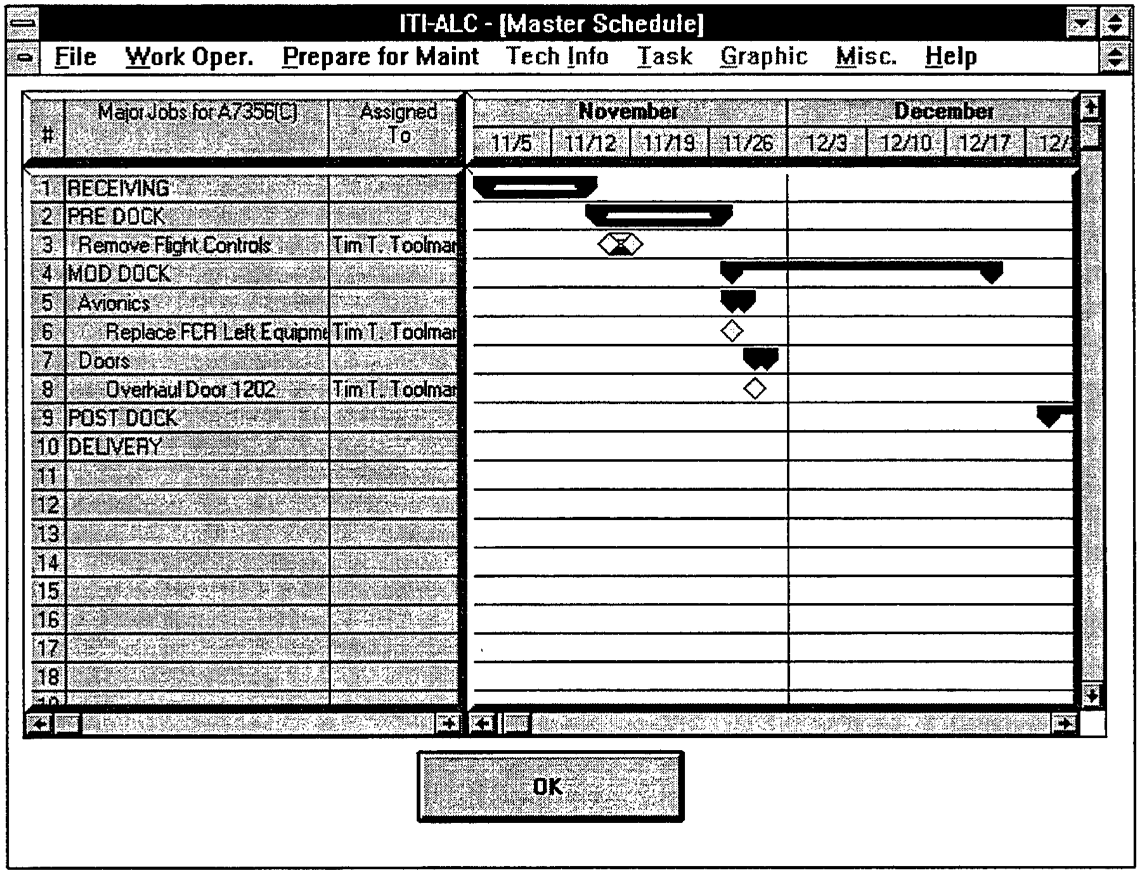
AIRCRAFT TAIL NO: A7356(C) S YSTEM : Fire Control Radar...

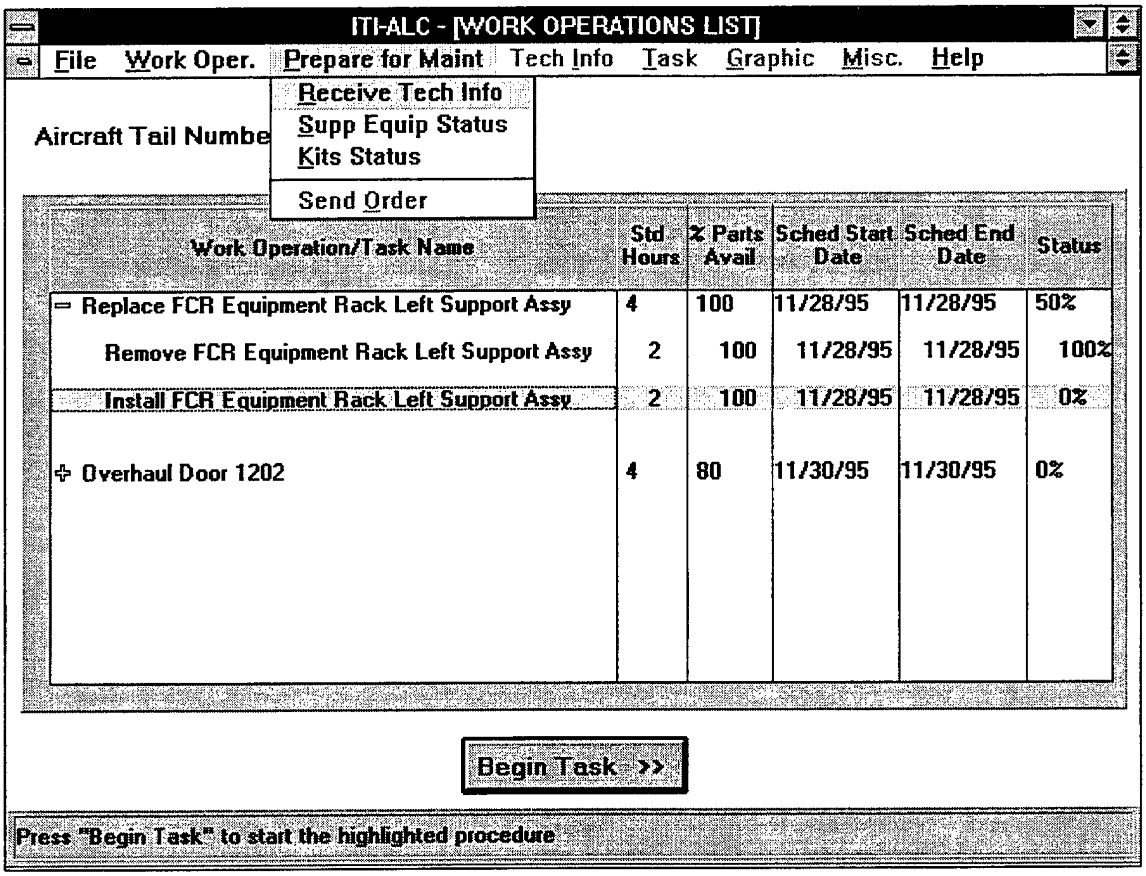
DATE	DISCREPANCY	CORRECTIVE ACTION	REPEAT/RECUR
10/24/95	MFL 004	Replace Antenna	Yes
8/8/95	MFL 084	Replace DMT	No
6/24/95	MFL 004	Replace Antenna	No
4/6/95	MFL 004	Replace Antenna	No
1/11/95	MFL 004	Wire Repair	No

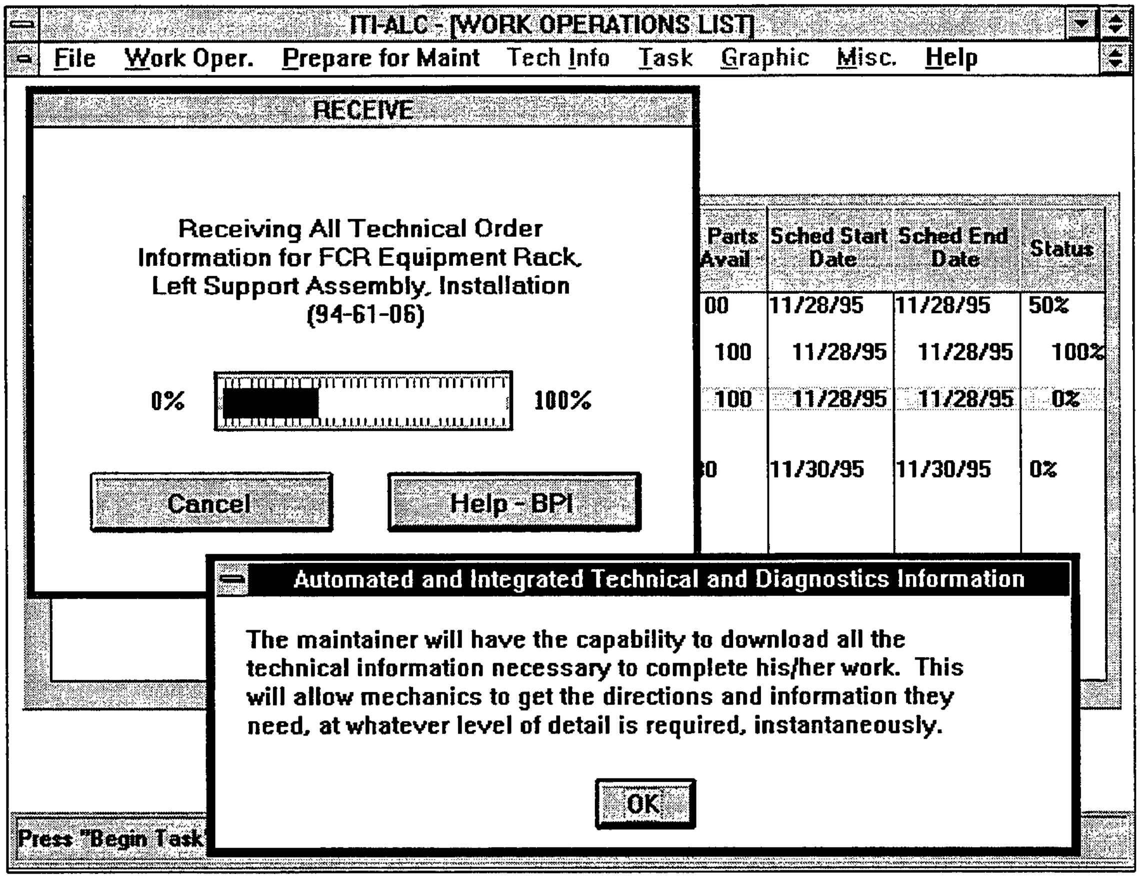
OK

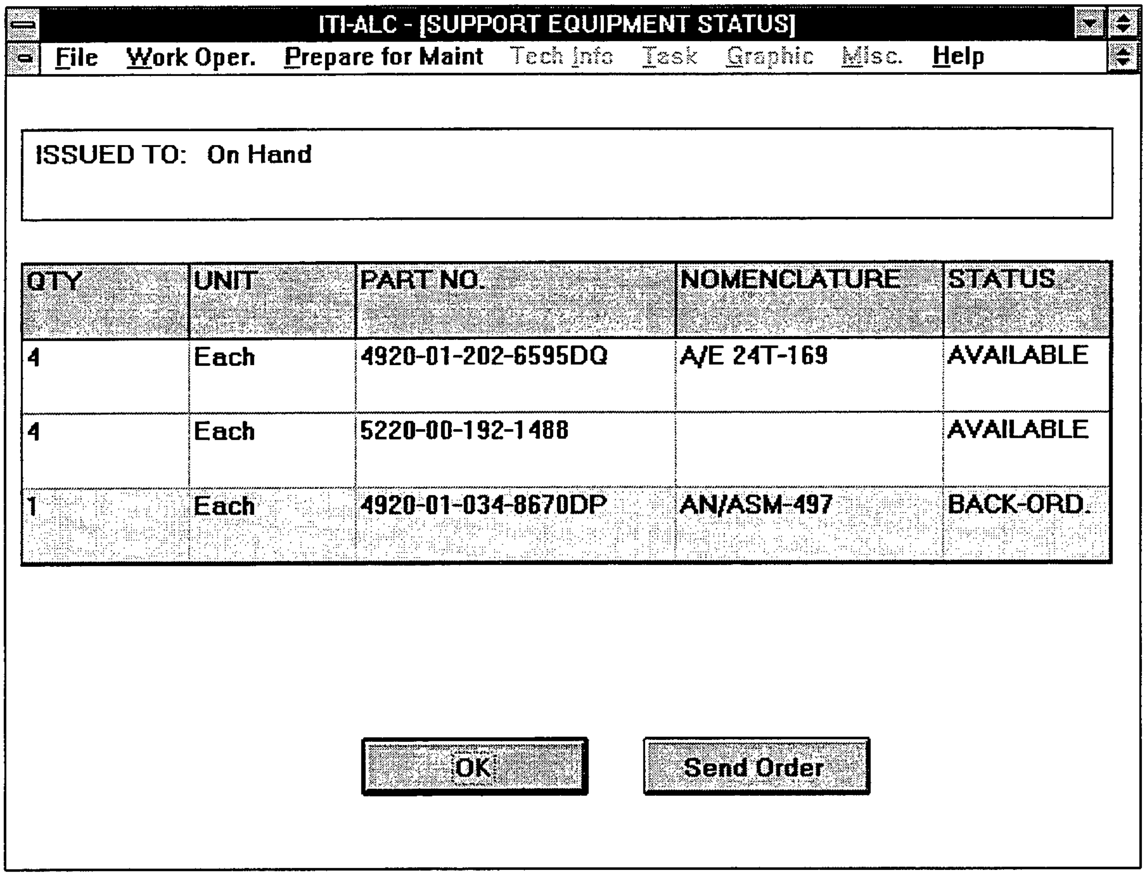
•User wants previous write ups to come up automatically when receiving the job


ITI-ALC - [ORGANIZATIONAL LEVEL HISTORY]
File Work Oper. Prepare for Maint Tech Info Task Graphic Misc. Help
AIRCRAFT TAIL NO: A7356(C)
S YSTEM : Fire Control Radar...
DATE DISCREPANCY CORRECTIVE ACTION REPEAT/RECUR
10/24/95 MFL 004 Replace Antenna Yes
8/8/95 MFL 084 Replace DMT No
6/24/95 MFL 004 Replace Antenna No
4/6/95 MFL 004 Replace Antenna No
1/11/95 M
Data Sharing Among All Levels of Maintenance
The O-Level History screen gives the maintainer visibility into previous actions performed on a certain aircraft at the flightline. This gives him/her an advantage in knowing information such as repeating and recurring faults.
OK
OK


ITI-ALC - [Master Schedule]
File Work Oper. Prepare for Maint Tech Info Task Graphic Misc. Help
#
Major Jobs for A7356(C)
Assigned To
November
December
11/5 11/12 11/19 11/26 12/3 12/10 12/17
1 RECEIVING
2 PRE DOCK
3 Remove Flight Controls Tim T. Toolman
4 MOD DOCK
5 Avionics
6 Replace FCR Left Equipm Tim T. Toolman
7 Doors
8 Overhaul Door 1202 Tim T. Toolman
9 POST DOCK
10 DELIVERY
11
12
13
14
15
16
17
18
OK


ITI-ALC - [WORK OPERATIONS LIST]
File
Work Oper.
Prepare for Maint
Tech Info
Task
Graphic
Misc.
Help
Receive Tech Info
Supp Equip Status
Kits Status
Send Order
Aircraft Tail Numbe
Work Operation/Task Name
Std Hours
% Parts Avail
Sched Start Date
Sched End Date
Status
Replace FCR Equipment Rack Left Support Assy 4 100 11/28/95 11/28/95 50%
Remove FCR Equipment Rack Left Support Assy 2 100 11/28/95 11/28/95 100%
Install FCR Equipment Rack Left Support Assy 2 100 11/28/95 11/28/95 0%
Overhaul Door 1202 4 80 11/30/95 11/30/95 0%
Begin Task >>
Press "Begin Task" to start the highlighted procedure


ITI-ALC - [WORK OPERATIONS LIST]
File Work Oper. Prepare for Maint Tech Info Task Graphic Misc. Help
RECEIVE
Receiving All Technical Order Information for FCR Equipment Rack, Left Support Assembly, Installation (94-61-06)
0%
100%
Cancel
Help - BPI
Parts Avail
Sched Start Date
Sched End Date
Status
11/28/95 11/28/95 50%
100 11/28/95 11/28/95 100%
100 11/28/95 11/28/95 0%
11/30/95 11/30/95 0%
Automated and Integrated Technical and Diagnostics Information
The maintainer will have the capability to download all the technical information necessary to complete his/her work. This will allow mechanics to get the directions and information they need, at whatever level of detail is required, instantaneously.
OK
Press "Begin Task



QTY	UNIT	PART NO.	NOMENCLATURE	STATUS
4	Each	4920-01-202-6595DQ	A/E 24T-169	AVAILABLE
4	Each	5220-00-192-1488		AVAILABLE
1	Each	4920-01-034-8670DP	AN/ASM-497	BACK-ORD.

•How to order was still not readily apparent

•Still looking for words

•Had cursor on Equipment several time but wasn't sure it was right and was
•uneasy to try

•Separate between AGE and Test equipment. Otherwise, don't know where to find AGE

•Should go ahead and say whether or not a job is supportable-give reasons, give delay times

ITI-ALC - [INVENTORY PARTS & KITS STATUS]

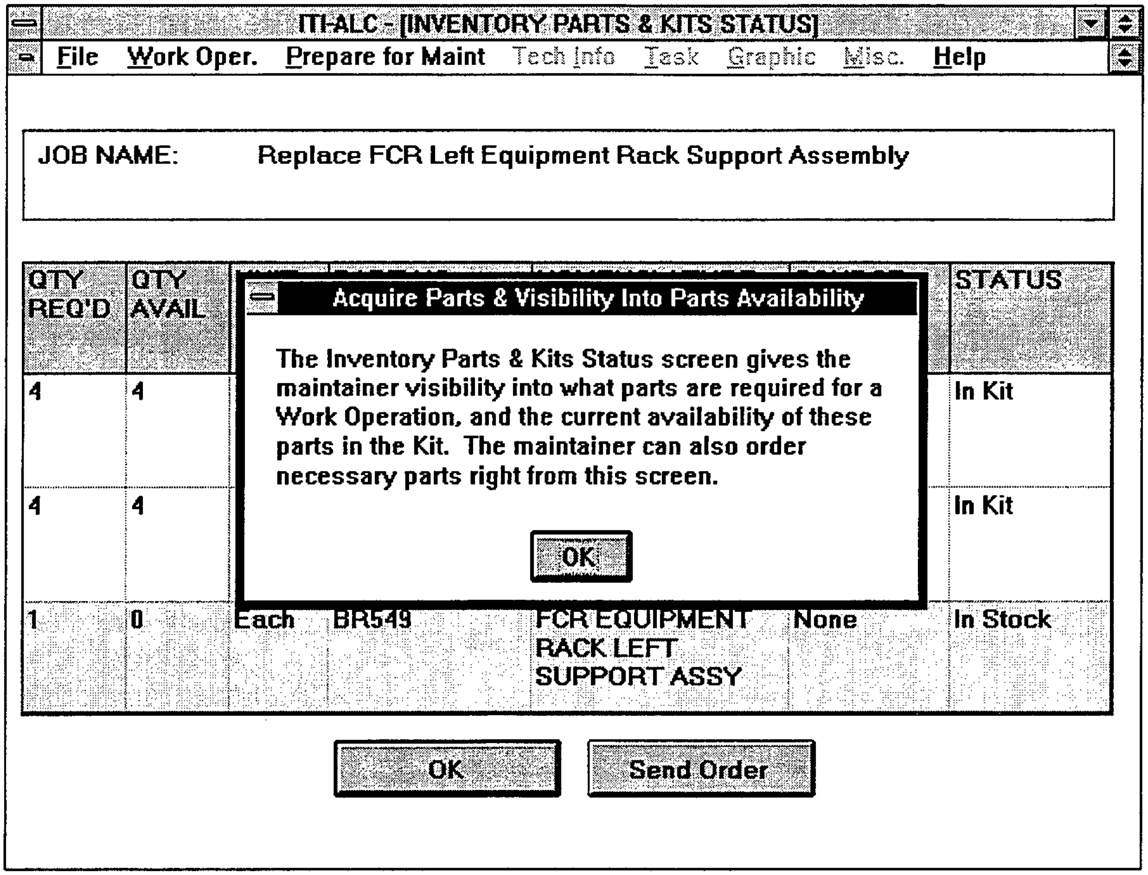
File Work Oper. Prepare for Maint Tech Info Task Graphic Misc. Help

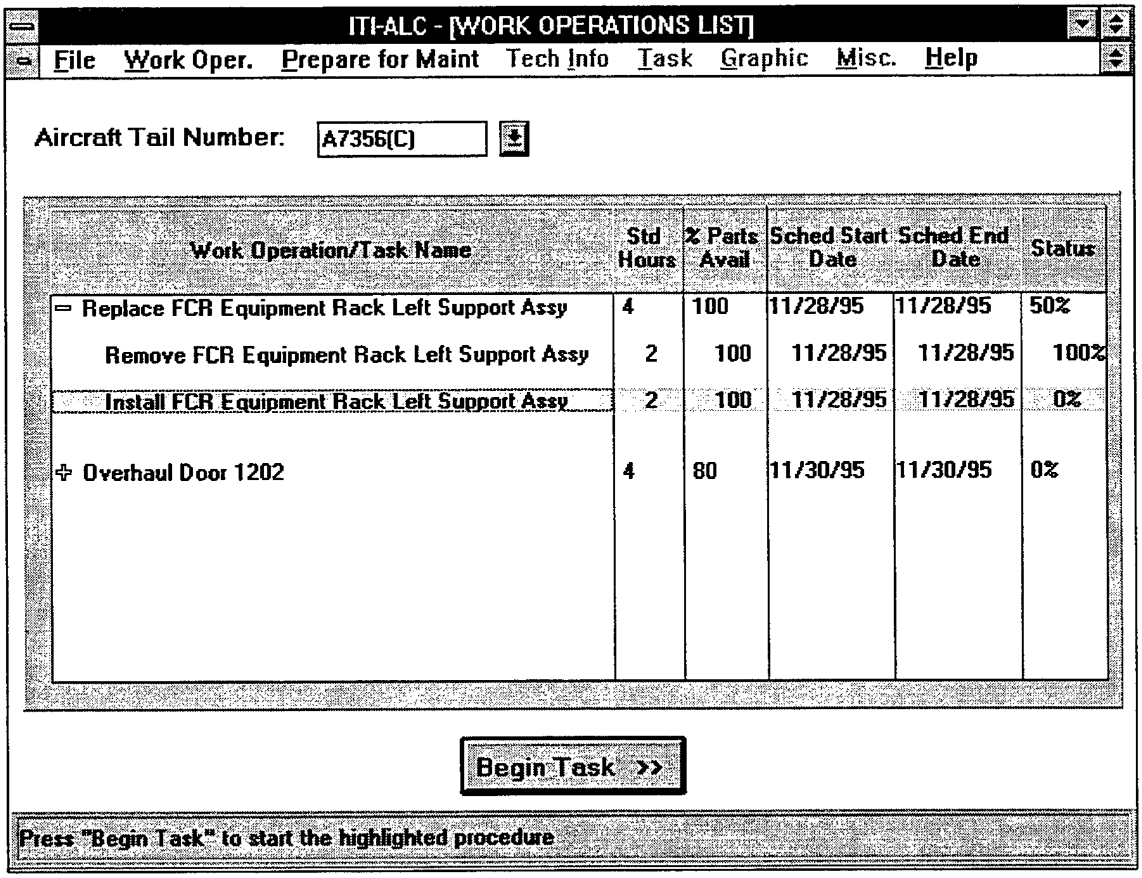
JOB NAME: Replace FCR Left Equipment Rack Support Assembly

QTY REQ'D	QTY AVAIL	UNIT	PART NO.	NOMENCLATURE	SOURCE	STATUS
4	4	Each	LQ-DK-112JF	MOUNT SCREWS	Supply	In Kit
4	4	Each	DK-LQ-111JF	WASHERS	Supply	In Kit
1	0	Each	BR549	FCR EQUIPMENT RACK LEFT SUPPORT ASSY	None	In Stock

OK Send Order

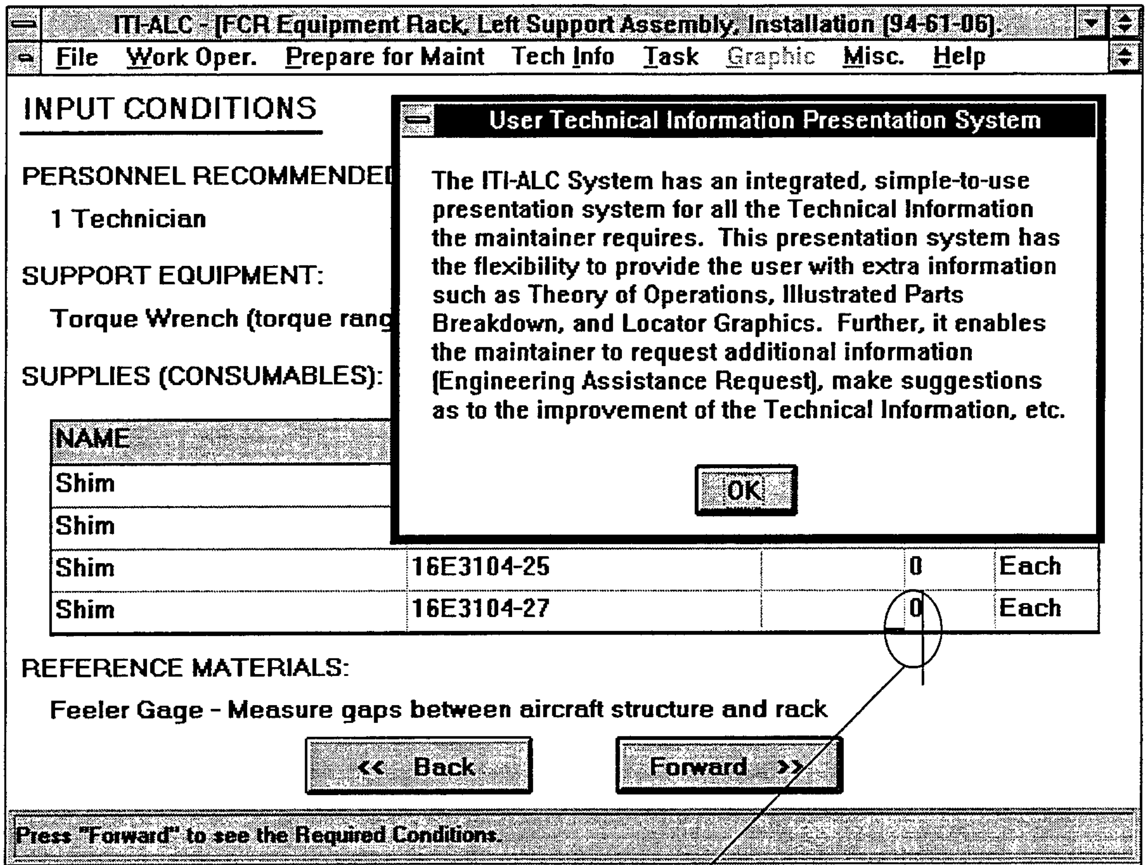
- Source of "none" confusing
- Still need status of ordered parts/equipment or else task can't be done


ITI-ALC - [INVENTORY PARTS & KITS STATUS]
File Work Oper. Prepare for Maint Tech Info Task Graphic Misc. Help
JOB NAME: Replace FCR Left Equipment Rack Support Assembly
QTY REQ'D
QTY AVAIL
STATUS
4
4
In Kit
4
4
In Kit
1
0
Each
BR549
FCR EQUIPMENT RACK LEFT SUPPORT ASSY
None
In Stock
Acquire Parts & Visibility Into Parts Availability
The Inventory Parts & Kits Status screen gives the maintainer visibility into what parts are required for a Work Operation, and the current availability of these parts in the Kit. The maintainer can also order necessary parts right from this screen.
OK
OK
Send Order



•Highlighted line below Install FCR...then tried to begin task

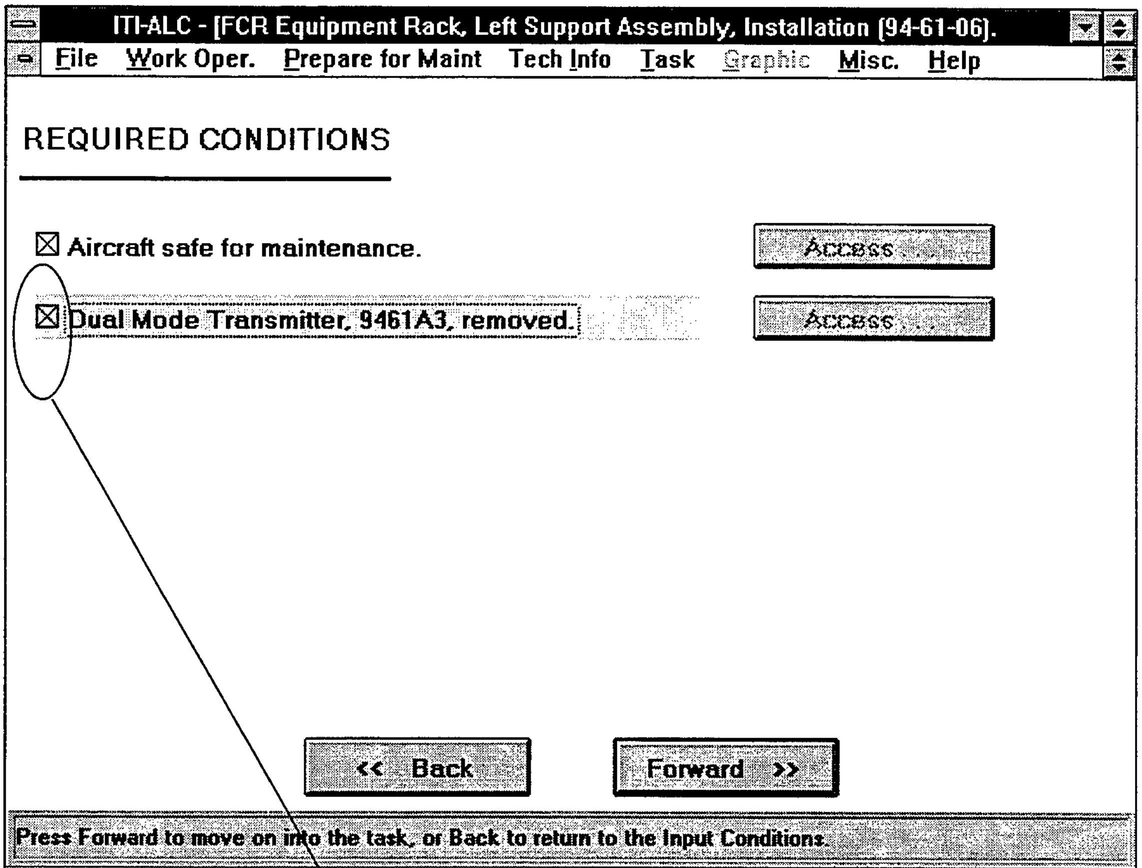
•Highlighted several other tasks, user was not sure what to do



•Double clicked to see kit info

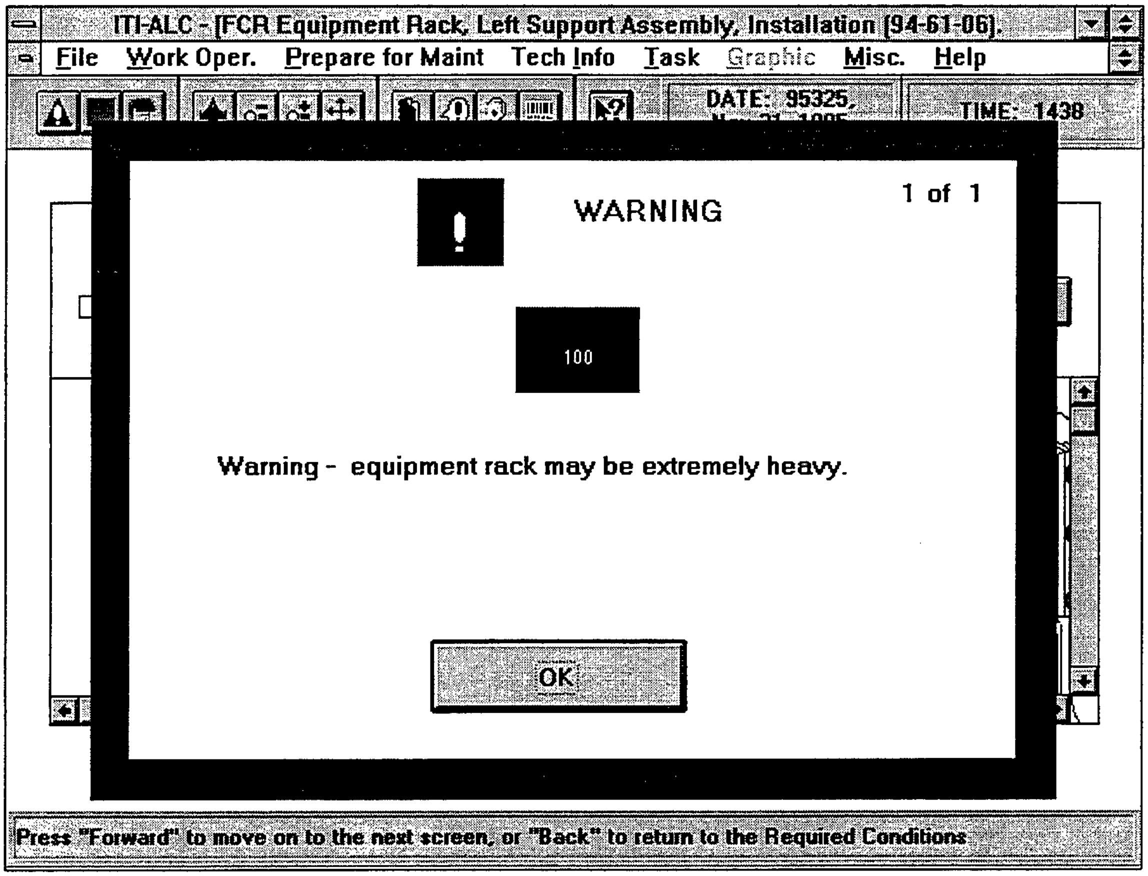
•Knowing exactly when you are ready to start the task is unclear

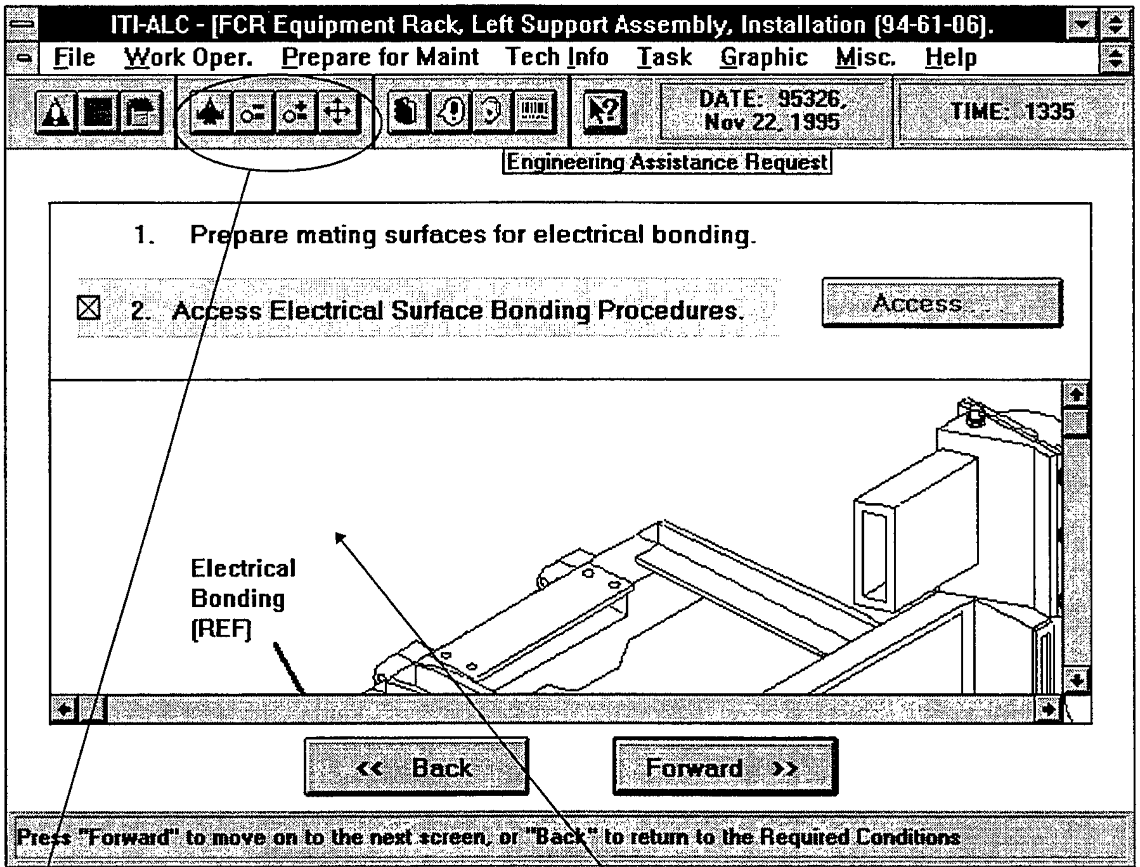
•Screens with no action ---no one knows where to proceed unless directed to on screen



•Double clicked several times

•Tough to determine navigation sequence

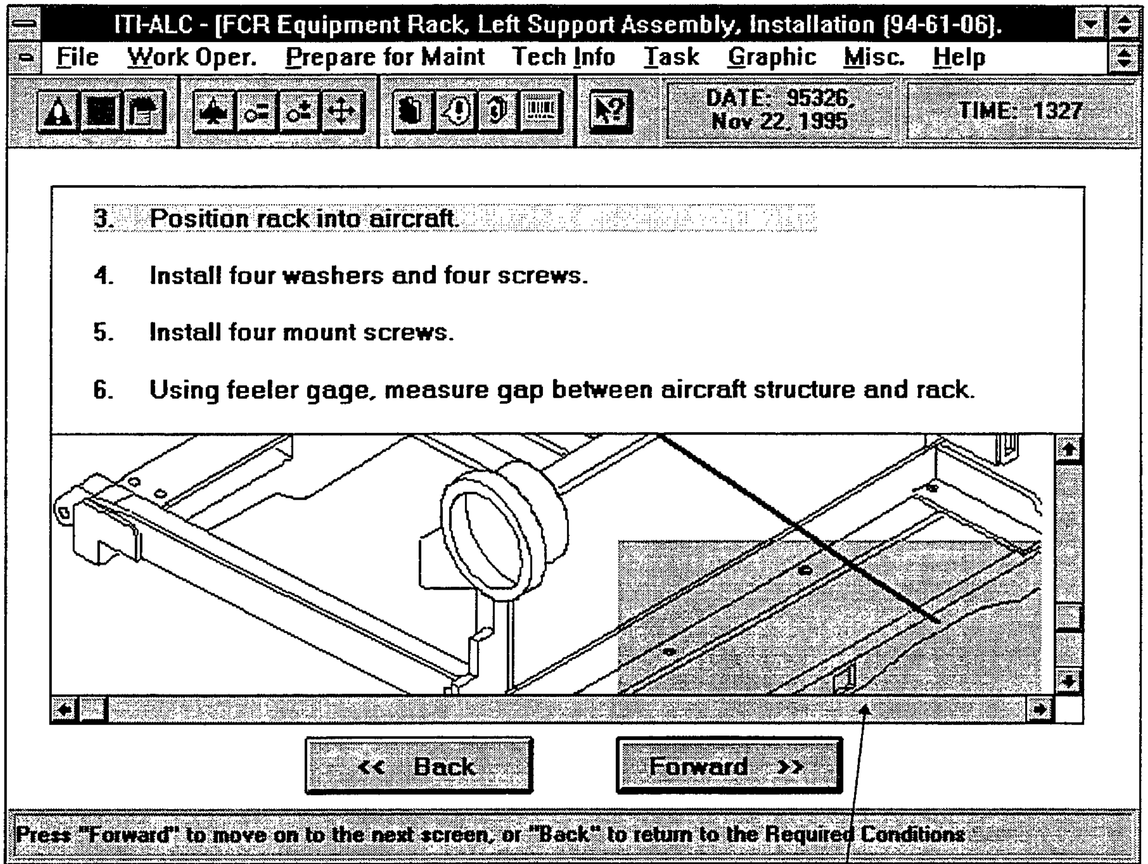

ITI-ALC - [FCR Equipment Rack, Left Support Assembly, Installation [94-61-06].
File
Work Oper.
Prepare for Maint
Tech Info
Task
Graphic
Misc.
Help
DATE: 95325,
TIME: 1438
WARNING
1 of 1
100
Warning - equipment rack may be extremely heavy.
OK
Press "Forward" to move on to the next screen, or "Back" to return to the Required Conditions



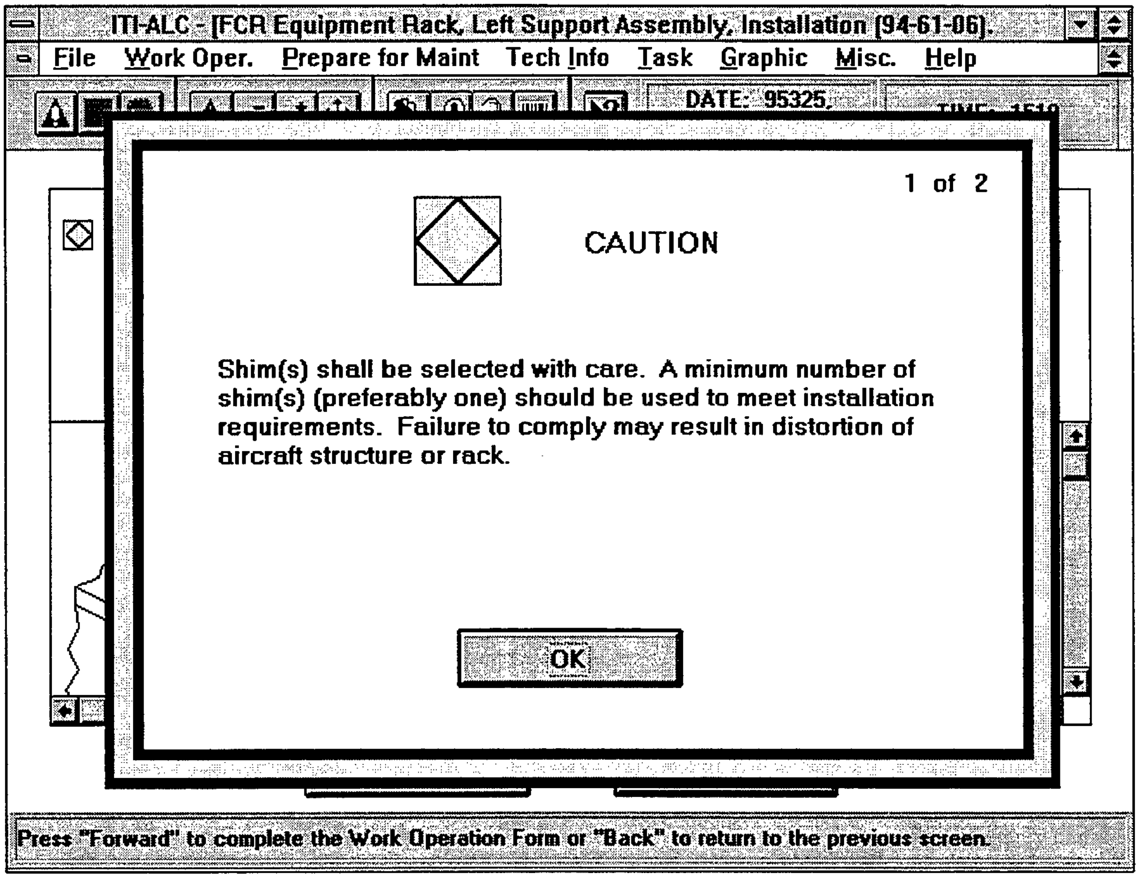
•Did not click on locator until second time, first clicked full screen

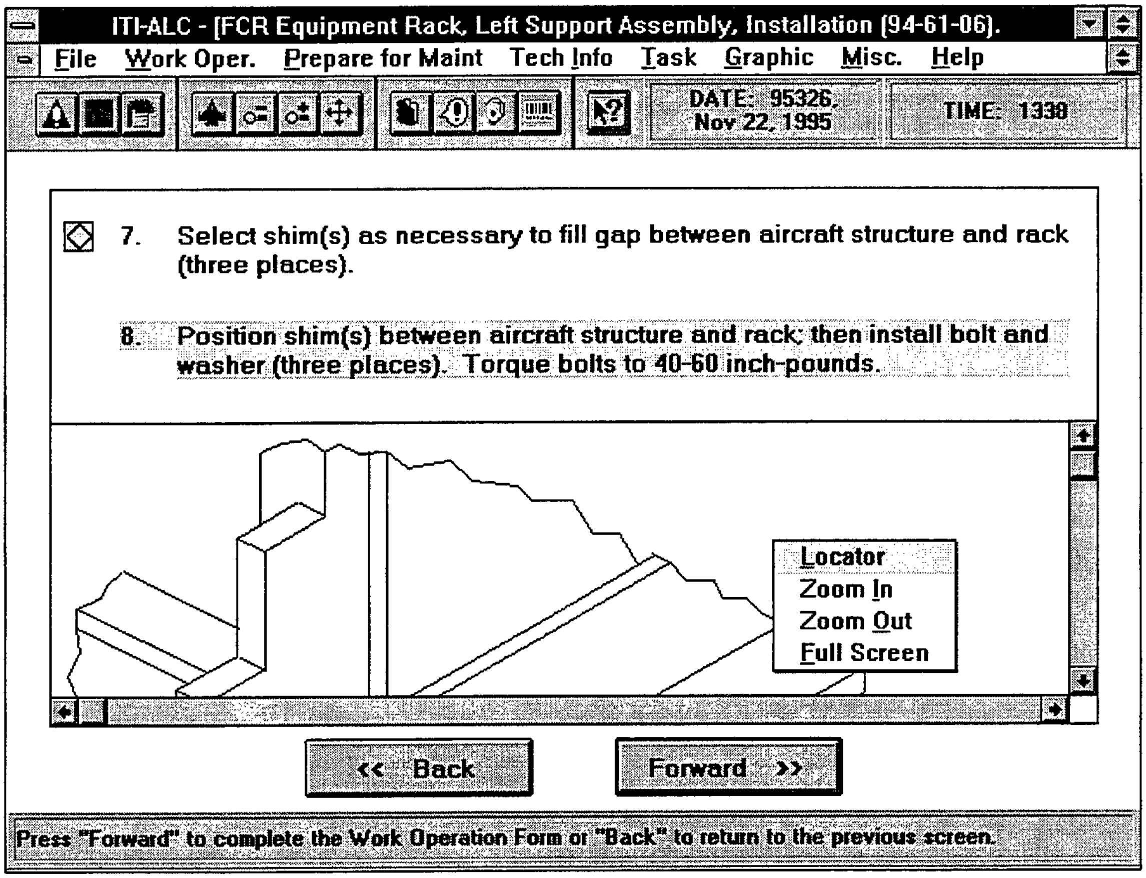
•Asked, "is this the size of the picture?"

•Could not find how to indicate elect. bonding complete

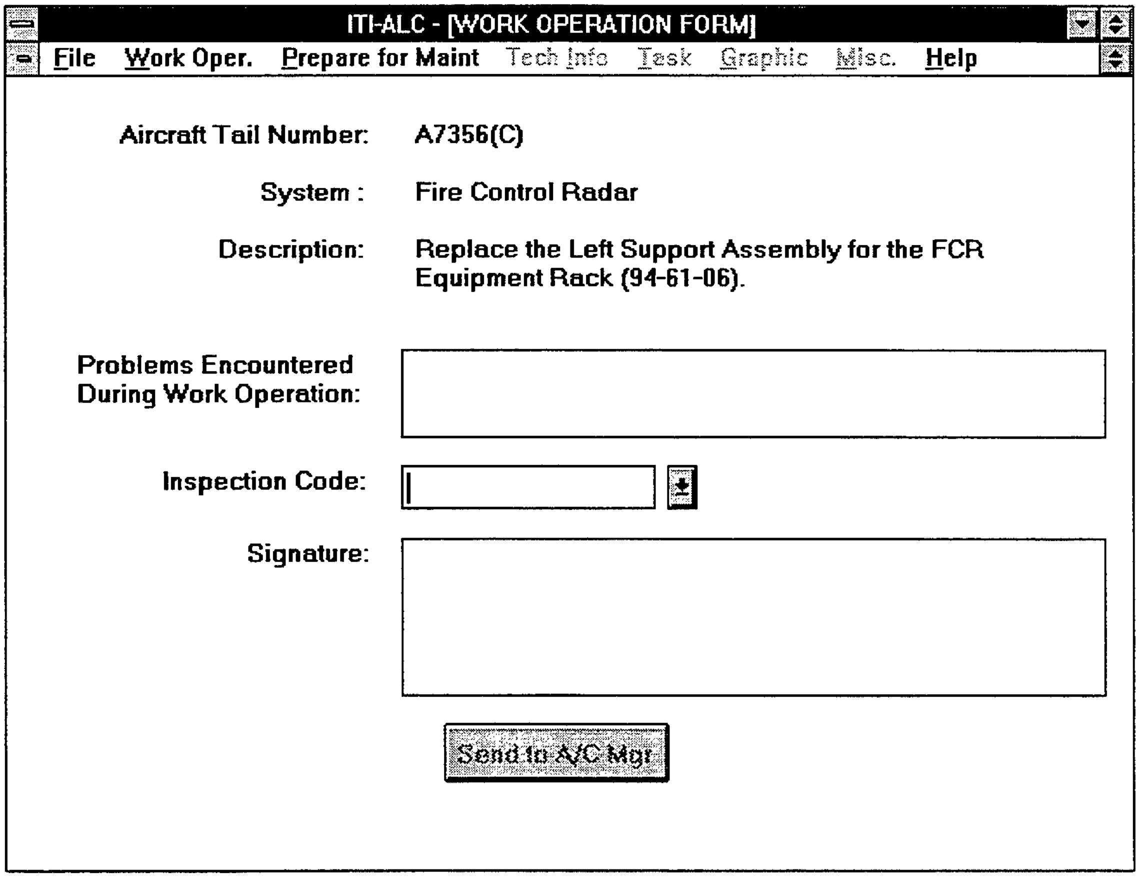


- T.O. error--graphic doesn't show the tolerances
- User unfamiliar with use of scroll bars
- Skipped hot spot, didn't look at the access door


ITI-ALC - [FCR Equipment Rack, Left Support Assembly, Installation [94-61-06].
File
Work Oper.
Prepare for Maint
Tech Info
Task
Graphic
Misc.
Help
DATE: 95325
1 of 2
CAUTION
Shim(s) shall be selected with care. A minimum number of shim(s) (preferably one) should be used to meet installation requirements. Failure to comply may result in distortion of aircraft structure or rack.
OK
Press "Forward" to complete the Work Operation Form or "Back" to return to the previous screen.



- Clicked on step 8 to change highlighting
- "Back" label on locator and Full Screen may be confusing
- Looking under "Graphic" menu bar to get back.
- couldn't get notes/cautions from icons or menus



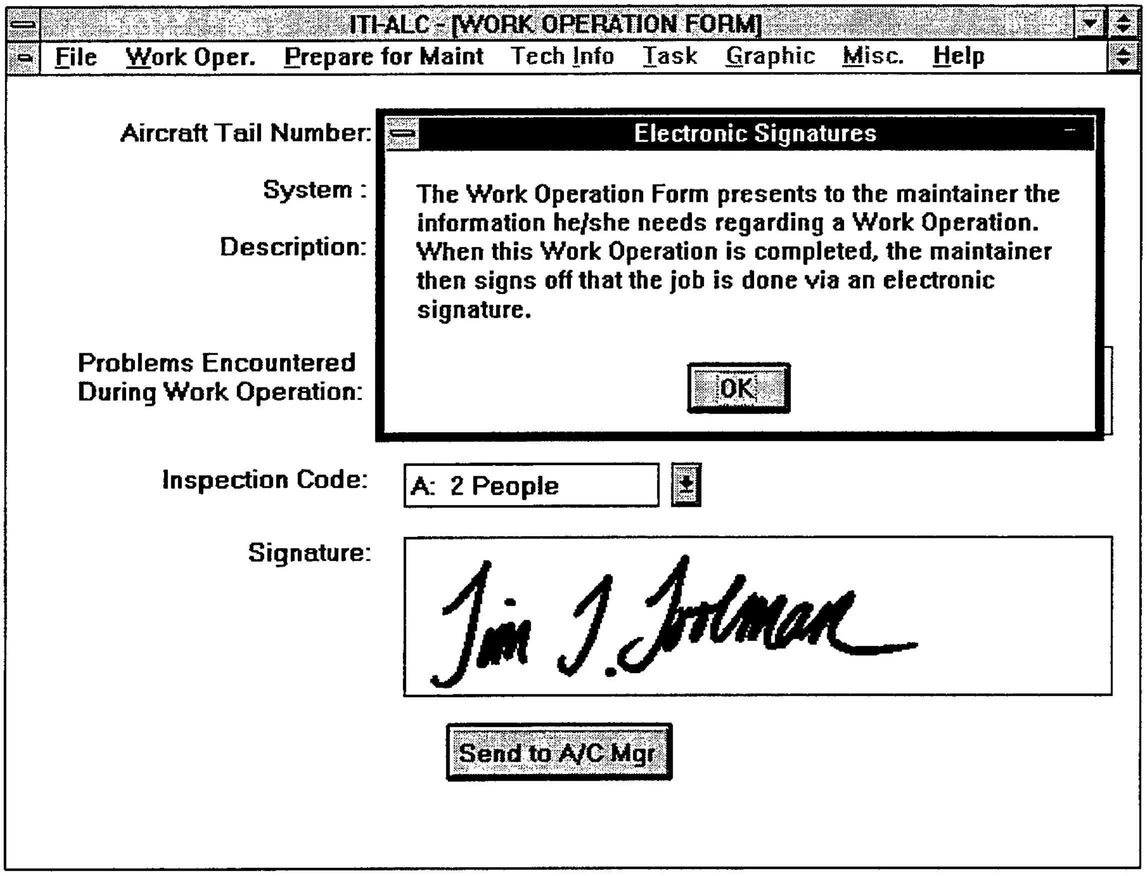
•Unfamiliar with menu, didn't go to file to find logout

•Went back and forth from "Work oper. to "Help" on menu 3 times

•B card should be displayed without ability to change to A card (1 inspector)

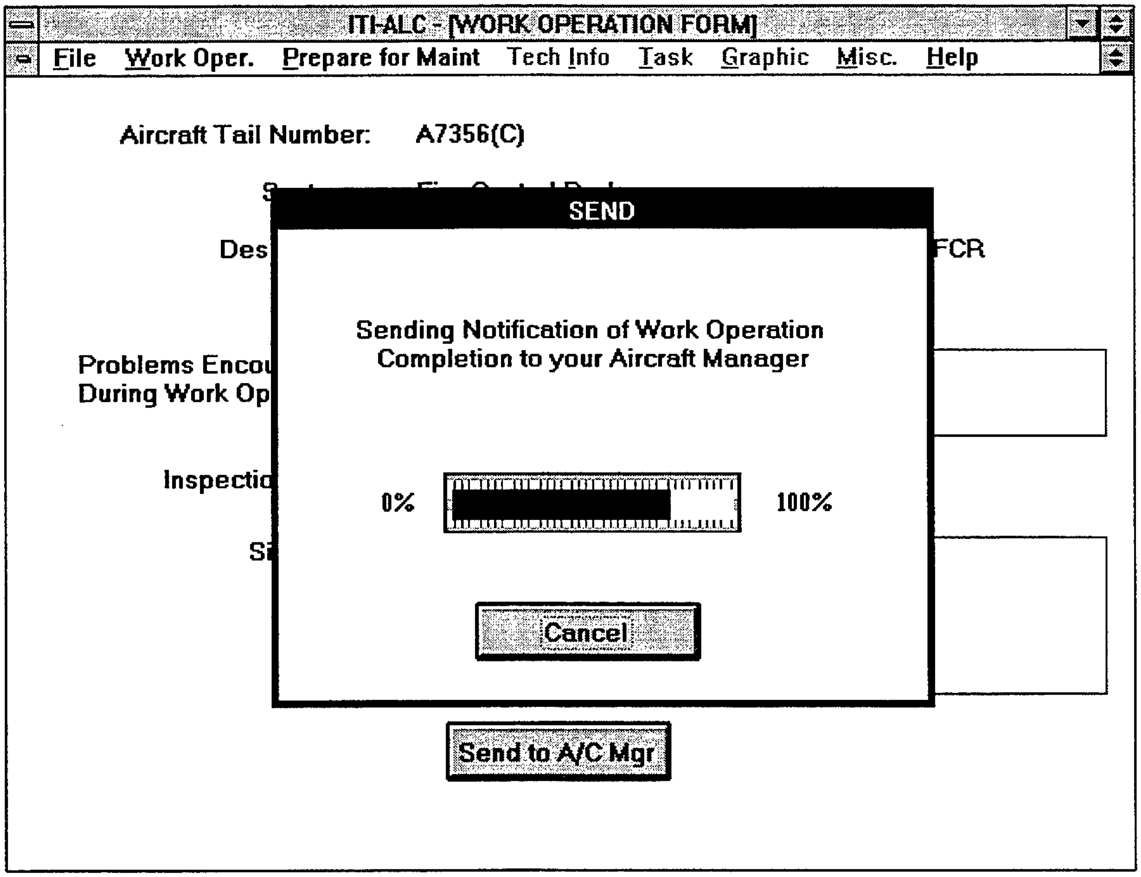
•No note that the last form is the 173. Looked for "173 card" under above menu items

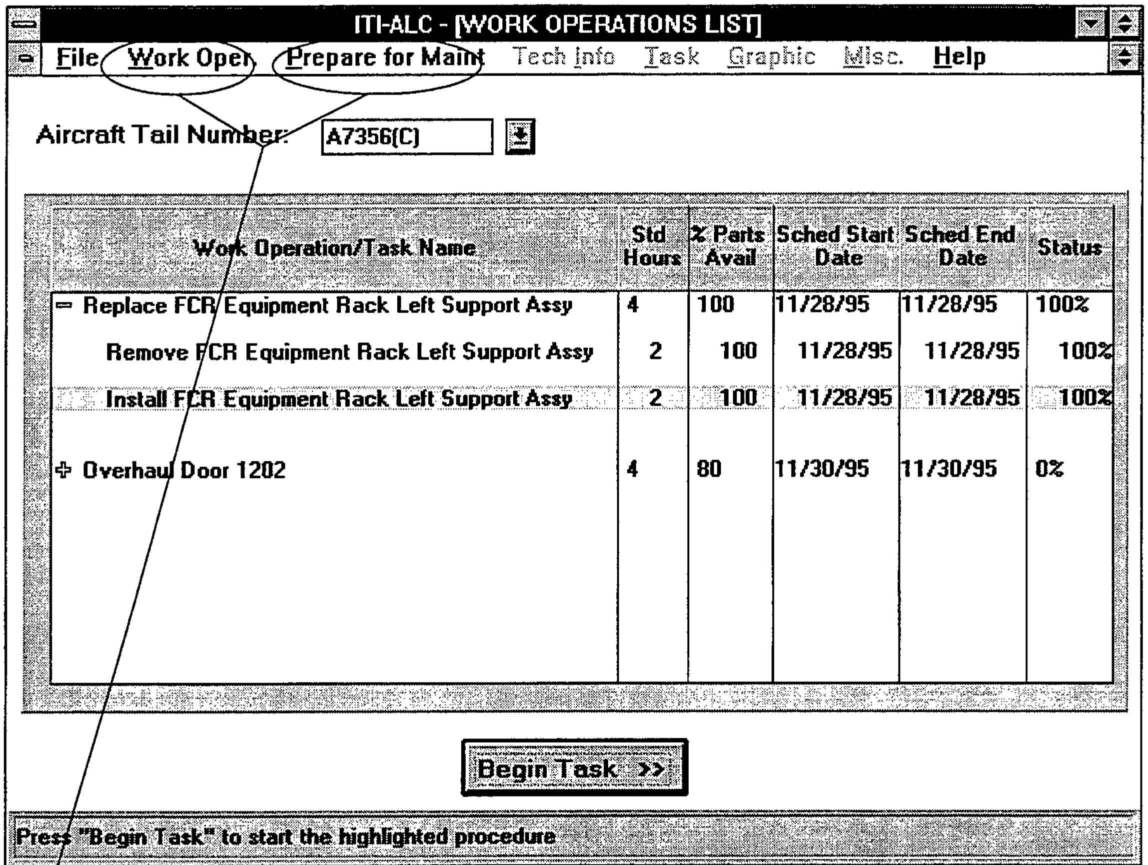
•Not worked as a "173 card"--confused with the first view of the form, from the menu which had no place for typed inputs



•People not used to clicking on an empty box. Short time to realize.

•Comment block is good but may be checked elsewhere. (e.g. why wasn't task equipment available)

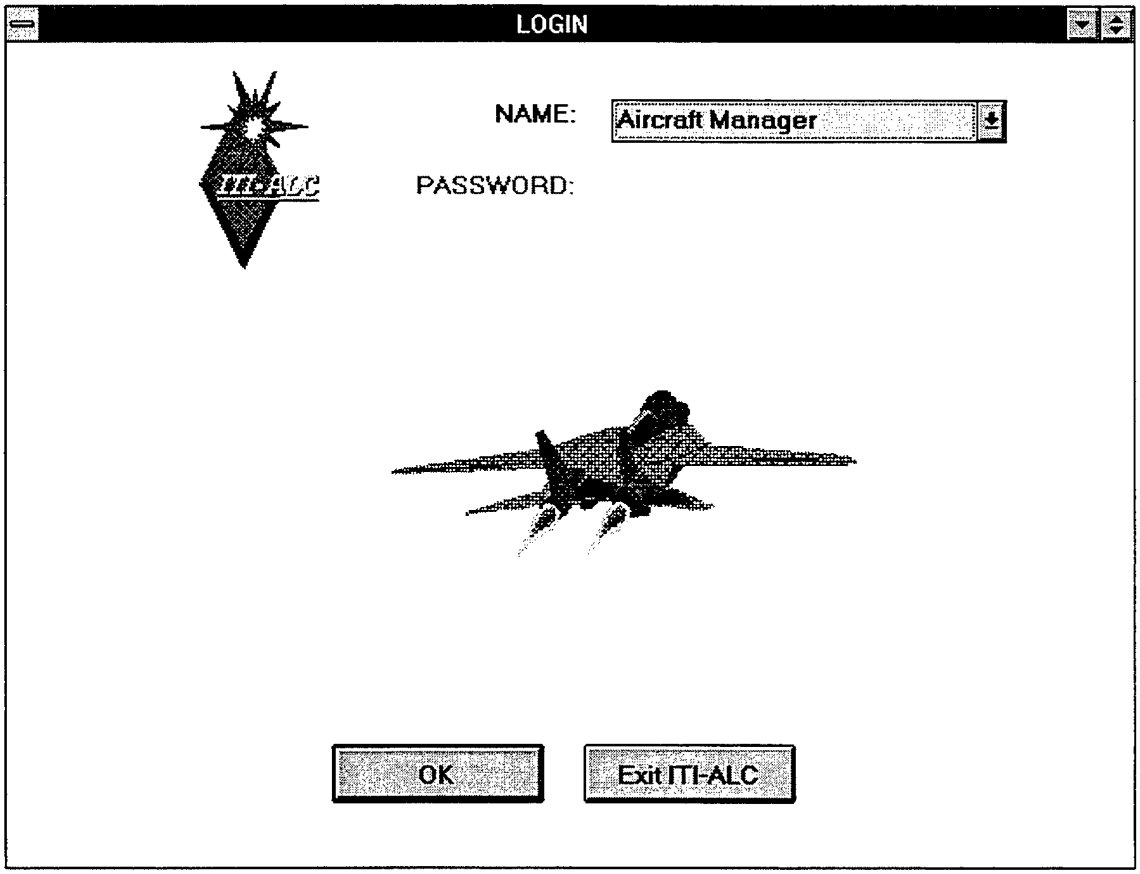

ITI-ALC - [WORK OPERATION FORM]
File Work Oper. Prepare for Maint Tech Info Task Graphic Misc. Help
Aircraft Tail Number: A7356(C)
Des
FCR
Problems Enco
During Work Op
Inspectio
Si
SEND
Sending Notification of Work Operation
Completion to your Aircraft Manager
0%
100%
Cancel
Send to A/C Mgr



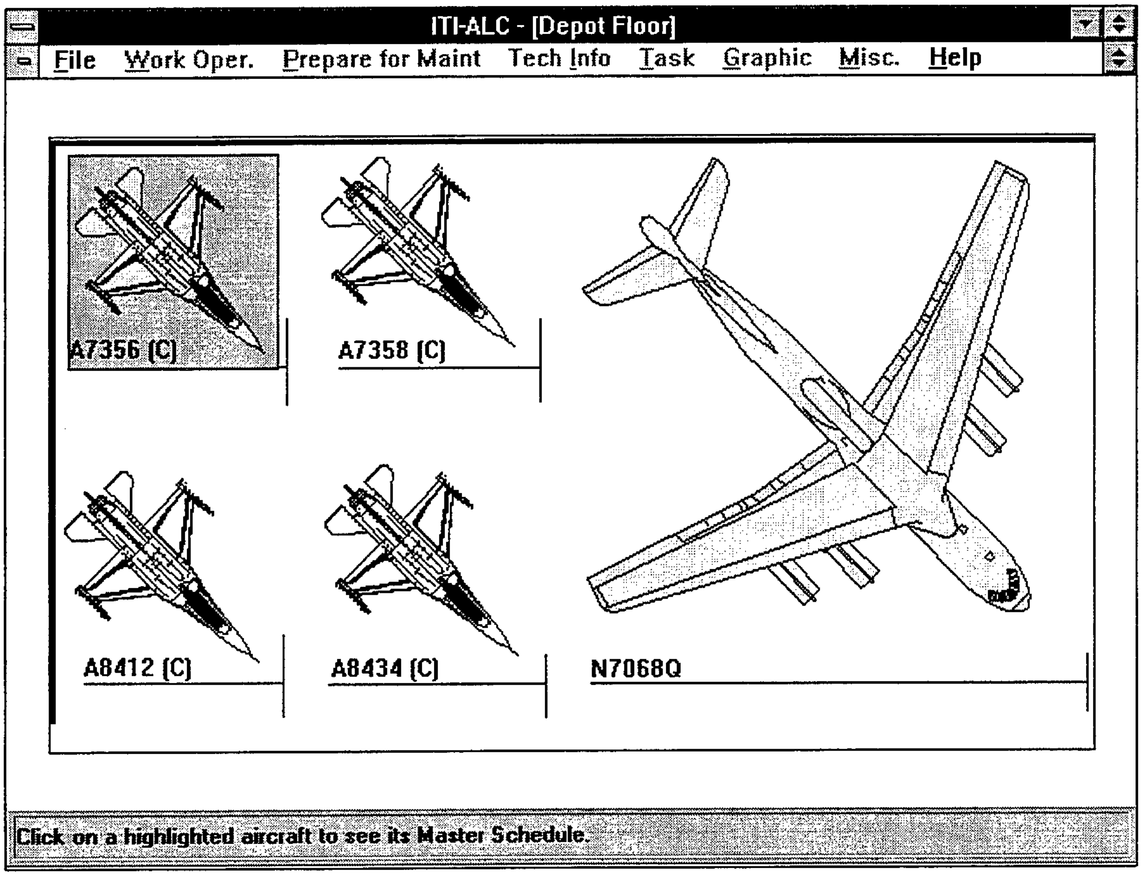
Work Operation/Task Name	Std Hours	% Parts Avail	Sched Start Date	Sched End Date	Status
− Replace FCR Equipment Rack Left Support Assy	4	100	11/28/95	11/28/95	100%
Remove FCR Equipment Rack Left Support Assy	2	100	11/28/95	11/28/95	100%
Install FCR Equipment Rack Left Support Assy	2	100	11/28/95	11/28/95	100%
+ Overhaul Door 1202	4	80	11/30/95	11/30/95	0%

- Sign off indicated in the scenario he thought meant sign off at end of task

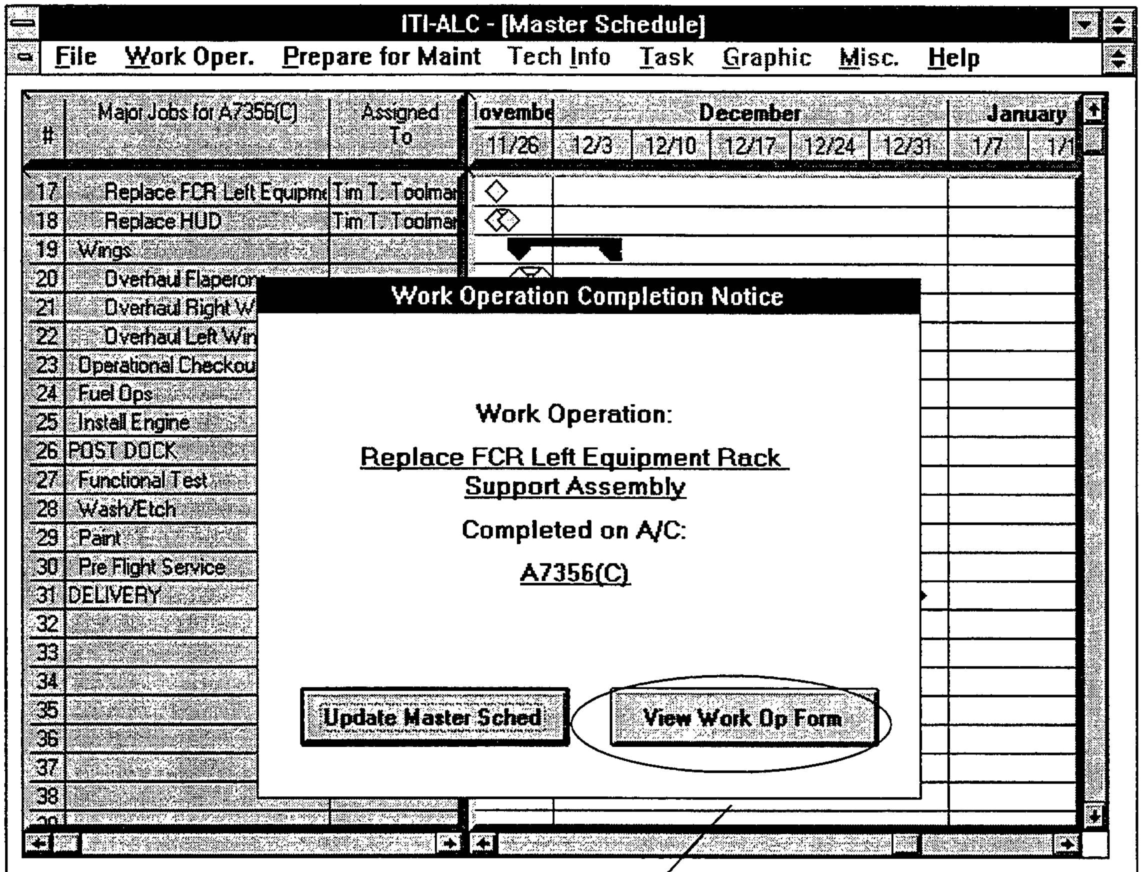
- Sign off was confusing
did not look under Logout



•Accidentally logged in as mechanic

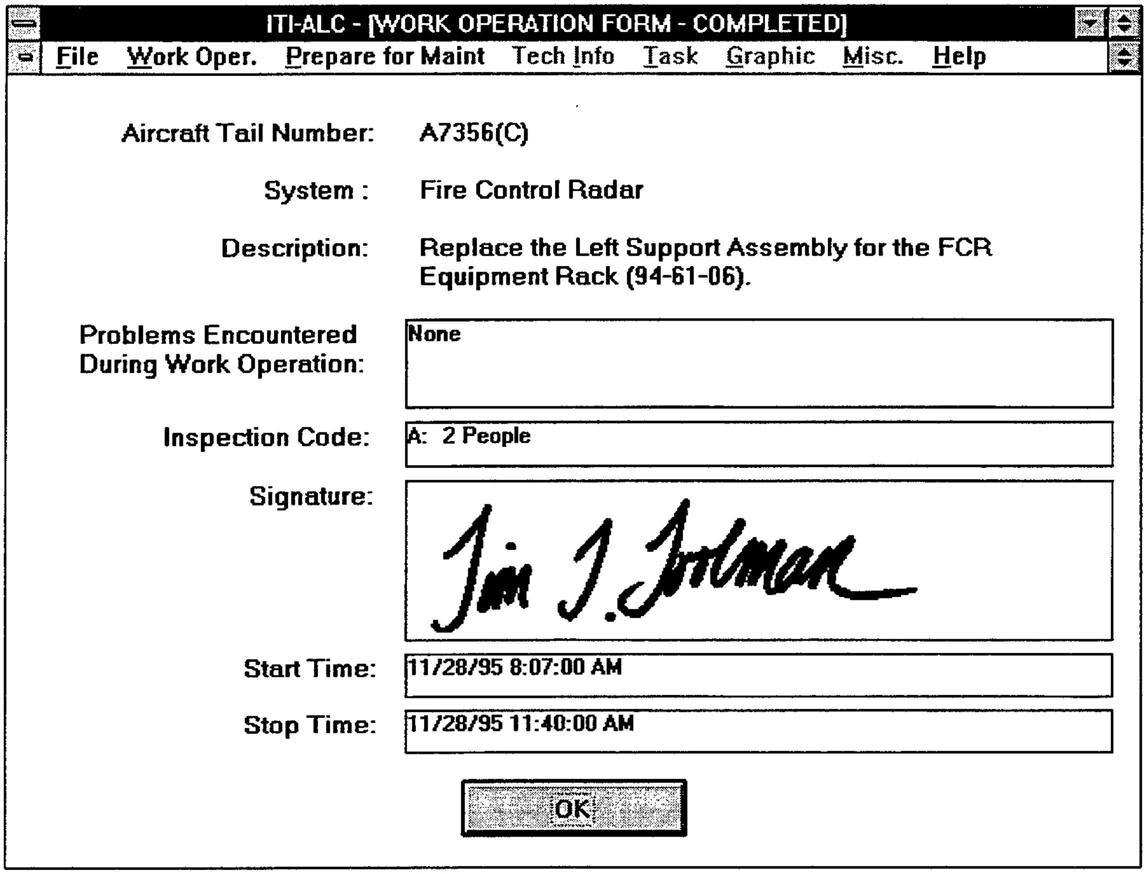


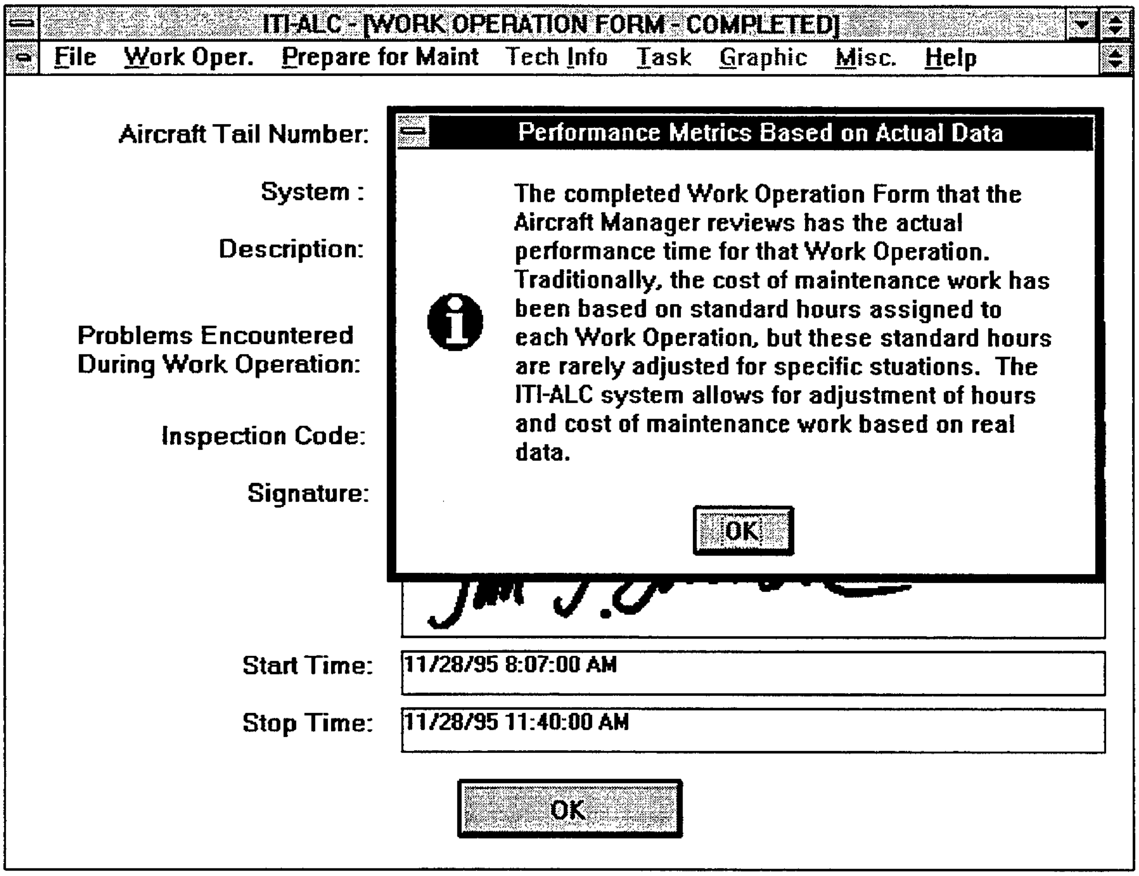
- Double clicked which brings up Task edit
- Double click, without cursor change, caused form update automatically

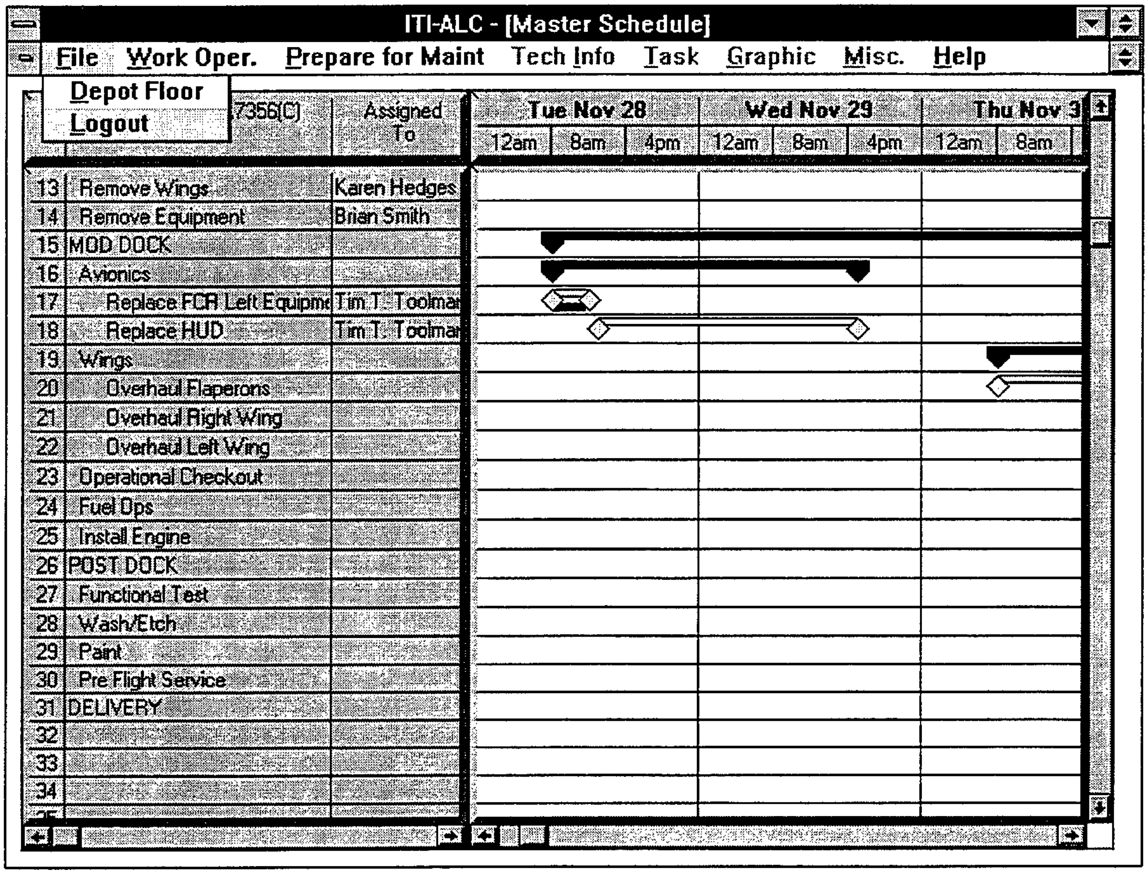


•This form should be model

•Skipped receiving


ITI-ALC - [WORK OPERATION FORM - COMPLETED]
File Work Oper. Prepare for Maint Tech Info Task Graphic Misc. Help
Aircraft Tail Number: A7356(C)
System : Fire Control Radar
Description: Replace the Left Support Assembly for the FCR Equipment Rack (94-61-06).
Problems Encountered During Work Operation: None
Inspection Code: A: 2 People
Signature:
Start Time: 11/28/95 8:07:00 AM
Stop Time: 11/28/95 11:40:00 AM
OK


ITI-ALC - [WORK OPERATION FORM - COMPLETED]
File Work Oper. Prepare for Maint Tech Info Task Graphic Misc. Help
Aircraft Tail Number:
System :
Description:
Problems Encountered During Work Operation:
Inspection Code:
Signature:
Performance Metrics Based on Actual Data
The completed Work Operation Form that the Aircraft Manager reviews has the actual performance time for that Work Operation. Traditionally, the cost of maintenance work has been based on standard hours assigned to each Work Operation, but these standard hours are rarely adjusted for specific stuations. The ITI-ALC system allows for adjustment of hours and cost of maintenance work based on real data.
OK
Start Time: 11/28/95 8:07:00 AM
Stop Time: 11/28/95 11:40:00 AM
OK



•Functions under tasks, names, calendar aren't clear. Wanted to see completion times on the graph but couldn't see them

Appendix I: Human Use Release Form

Informed Consent Document
for
New Technologies for Maintenance
and Logistics Information System Studies

1. Nature and Purpose: I have been asked to volunteer as a subject in the project named above. The purpose of these studies is to test and evaluate candidate technologies for maintenance and logistic information systems. The studies will help to determine the best way to design various features of the systems. The present study is designed to perform an evaluation of a rapid prototype developed for the Integrated Technical Information for the Air Logistics Center (ITI-ALC) program. For this study, one session with a duration of one day is required.

2. Experimental procedures: Each user will be required to evaluate the ITI-ALC rapid prototype and document the comments and findings of their evaluation using a group support system.

3. Discomfort and risk: I understand that participation in the study will not involve risks greater than those encountered in performing my normal duties. Working conditions will be similar to those encountered in my normal duties.

4. Precautions for female subjects: The study does not involve risks specific to females. Therefore, no special precautions are required.

5. Benefits: There is no direct financial or medical benefits to the subject. However, participation provides the opportunity for the subject to contribute to the design and development of future Air Force information systems.

6. Entitlements and confidentiality:

a. Records of participation in this study may only be disclosed according to federal law, including the Federal Privacy Act, 5 U.S.C. 552a, and its implementing regulations.

b. I understand that my entitlements to medical and dental care and/or compensation in the event of injury are governed by federal laws and regulations, and that if I desire further information I may contact the base legal office.

c. If an unanticipated event (medical misadventure) occurs during my participation in this study, I will be informed. If I am not competent at the time to understand the nature of the event, such information will be brought to the attention of my next of kin.

d. The decision to participate in this research is completely voluntary on my part. No one has coerced or intimidated me into participating in this program. I am participating because I want to. Capt Allen Gwartney AFIT/LAA, 57777 x 2244 has adequately answered any and all questions I have about this study, my participation, and the procedures involved. I understand that Capt Allen Gwartney will be available to answer any questions concerning procedures throughout this study. I understand that if significant new findings develop during the course of this research which may relate to my decision to continue participation, I will be informed. I further understand that I may withdraw this consent form at any time and discontinue further participation in this study without prejudice to my entitlements. I also understand that the medical monitor of this study may terminate my participation in this study if he or she feels this to be in my best interest.

____________________________ ________

Volunteer Signature and SSN Date

____________________________ ________

Investigator Signature and SSN Date

____________________________ ________

Witness Signature and SSN Date

Appendix J: List of Acronyms

AFIT	Air Force Institute of Technology
AFTO	Air Force Technical Order
AGE	Aerospace Ground Equipment
AL	Armstrong Laboratory
ALC	Air Logistics Center
BPI	Business Process Improvement
CALS	Continuous Acquisition Life-Cycle Support
DoD	Department of Defense
FCR	Fire Control Radar
GSS	Group Support System
GUI	Graphical User Interface
HCI	Human Computer Interface
IDEF	Integrated Definition Methodology
ITI-ALC	Integrated Technical Information for the Air Logistic Centers
Mhz	Mega-Hertz
PDM	Programmed Depot Maintenance
RF	Radio Frequency
SRA	System Research and Application Corporation
T.O.	Technical Order
TCTO	Time Compliance Technical Order

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Vita

Captain Floyd A. Gwartney was born on 9 December 1963 in Elk City, Oklahoma. He graduated from Oklahoma State University in 1988 with a Bachelor of Science Degree in Mechanical Engineering. After receiving his commission into the United States Air Force and completing the Aircraft Maintenance Officers Course (AMOC), Capt Gwartney was assigned to the 50th Tactical Fighter Wing (TFW) at Hahn AB, Germany.

During his tour at Hahn AB, Captain Gwartney performed a variety of maintenance duties in support of the F-16C/D aircraft and the 50th TFW missions. These duties included Officer in Charge of the Maintenance Operations Center (MOC), Officer in Charge of the Aircraft Branch, and Assistant Officer in Charge of the 10th Aircraft Maintenance Unit (AMU). While in the 10th AMU, Captain Gwartney deployed to the Gulf Region in support of Desert Shield/Storm. After returning, he was assigned to Armstrong Laboratory, Logistics Research Division at Wright-Patterson AFB, OH.

During his tour at Wright-Patterson AFB within the Armstrong Laboratory, Captain Gwartney performed the duties of Aircraft Maintenance Research Officer and later the Senior Maintenance Research Officer. In 1995, Captain Gwartney entered the Air Force Institute of Technology and graduated in 1996 with a Masters degree in Logistics Management. He was subsequently assigned to Air Combat Command at Langley AFB, VA as Chief of Airlift Planning.

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1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE September 1996	3. REPORT TYPE AND DATES COVERED Master's Thesis	
4. TITLE AND SUBTITLE *ASSESSING USER REQUIREMENTS FOR AN AUTOMATED SYSTEM TO SUPPORT PROGRAMMED DEPOT MAINTENANCE THROUGH THE USE OF A RAPID PROTOTYPE IN A GROUP SUPPORT SYSTEM ENVIRONMENT*			5. FUNDING NUMBERS
6. AUTHOR(S) Floyd A. Gwartney, Captain, USAF			
7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S) Air Force Institute of Technology 2750 P Street WPAFB OH 45433-7765			8. PERFORMING ORGANIZATION REPORT NUMBER AFIT/GTM/LAR/96S-7
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) OL AL HSC/HRGO Attn: Ms. Barbara Masquelier 2698 G Street WPAFB, OH 45433-7604			10. SPONSORING / MONITORING AGENCY REPORT NUMBER
11. SUPPLEMENTARY NOTES			
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution unlimited			12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 Words)*

The purpose of this thesis was to assess user requirements for an automated information system to support programmed depot maintenance (PDM). To accomplish this, the Integrated Technical Information for the Air Logistics Centers (ITI-ALC) program's rapid prototype was evaluated. The evaluation focused on users' perception of how well the prototype met system and human computer interface requirements for PDM technicians and managers. A group support system (GSS) was used as an analysis tool to evaluate the prototype and collect evaluation data. Using the prototype as a requirements baseline for the ITI-ALC system, this thesis had three objectives: to perform an assessment of the prototype and illicit modifications; to determine prototype compatibility with user's needs; and to investigate using GSS for prototype analysis. A total of seven users composed of PDM technicians and supervisors evaluated the prototype by following a scenario, and documenting their ideas using the GSS. Results indicate the prototype functionally meets user's requirements, however suggested modifications to enhance the prototype and gain more user acceptance. Results also indicate that a GSS is effective and efficient for performing prototype analysis. The primary recommendation was to make suggested changes and perform further tests to refine the ITI-ALC system baseline.

14. SUBJECT TERMS			15. NUMBER OF PAGES
Prototypes, User Needs, Decision Support Systems, Interfaces, Requirements, Aircraft Maintenance, Maintenance Management, Management Information Systems, Automation, Information Systems			182
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED	18. SECURITY CLASSIFICATION OF THIS PAGE UNCLASSIFIED	19. SECURITY CLASSIFICATION OF ABSTRACT UNCLASSIFIED	20. LIMITATION OF ABSTRACT UNCLASSIFIED

AFIT Control Number AFIT/GTM/LAR/96S-7

AFIT RESEARCH ASSESSMENT

The purpose of this questionnaire is to determine the potential for current and future applications of AFIT thesis research. **Please return completed questionnaire** to: AIR FORCE INSTITUTE OF TECHNOLOGY/LAC, 2950 P STREET, WRIGHT-PATTERSON AFB OH 45433-7765. Your response is **important.** Thank you.

1. Did this research contribute to a current research project? a. Yes b. No

2. Do you believe this research topic is significant enough that it would have been researched (or contracted) by your organization or another agency if AFIT had not researched it?
a. Yes b. No

3. **Please estimate** what this research would have cost in terms of manpower and dollars if it had been accomplished under contract or if it had been done in-house.

Man Years__________ $__________

4. Whether or not you were able to establish an equivalent value for this research (in Question 3), what is your estimate of its significance?

a. Highly Significant b. Significant c. Slightly Significant d. Of No Significance

5. Comments (Please feel free to use a separate sheet for more detailed answers and include it with this form):

Name and Grade

Organization

Position or Title

Address